Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

JULY, 1915.

THE TRAGEDY OF TARAWERA, NEW ZEALAND.

By MARY PROCTOR.

PROBABLY the most weird and wonderful region in New Zealand is at Tarawera, the scene of a tragedy which occurred in 1886. To reach Tarawera the tourist is taken in a launch across the hot lake Rotomahana, and the cruise is usually a thrilling experience. The stream-jets ascending from the surrounding cliffs seem like spurts from a huge cauldron hidden amid the recesses in the rocks. Boiling water is ejected in great force from numberless jets overflowing into the lake. Doubts concerning the boiling water in the lake were soon settled, for a member of our party, doubting the statement of the guide to that effect, tested its warmth for himself, with disastrous results.

Our attention was called to the former site of the peerless Pink and White Terraces (see Figures 174 and 175), which made this region one of the great marvels of the world. They now lie buried under ninety feet of mould and ashes, due to the eruption of the great volcano Tarawera. The Terraces consisted of two immense terraced slopes, formed by the action of the downward-dropping hot water, heavily loaded with silica. Every terrace contained a succession of fairy-like baths and basins, filled with water tinted either bright blue, ivory white, or a faint tinge of bright pink.

The exquisite natural carvings and flutings formed by the dripping water, the beautiful tints of the terraces, the blue of the sky overhead reflected in the lake beneath—all combined to form a picture the like of which does not exist on earth to-day. Sometimes the Terraces, when illuminated by the sunshine, glittered with opal hues, arising from the action of light upon the water rippling downwards to the lakes. The marvellous structure was due to the action of a geyser suddenly opening on the hillside. The destruction of the Terraces in 1886 was caused by the eruption of Tarawera. Perhaps no one regretted their loss as deeply as Sophia, the old Tarawera guide, whose native name, "Hingerangi," means "Young Girl in Heaven." She was born at Russell, Bay of Islands, in 1830, her father, Alexander Grey, being a Scotchman; and her mother, Hingerangi, a pure-blooded Maori of the Tohurangi tribe. In her younger days, we are told, she was a pretty girl, and even at the time of the eruption of Tarawera she was a striking-looking woman. Those who heard her relate her thrilling story of the awful catastrophe of June 10th, 1886, were deeply impressed by her striking language and dramatic gestures, as with flashing eyes she described her terrible experience on that night of horror.

A STRANGE SIGHT.

"They are gone—quite gone—those lovely Terraces," was her lament as she pointed to the place where the water now flows, hiding for ever from view that lovely work of Nature. About a week before the eruption Sophia had noticed, while taking a party of tourists to Lake Rotomahana, that there was no water in the creek, and the boats were embedded in mud. Presently the water began to come up with a crying sound all along the shores of the lake, and it floated the boats up and up, and went over to the waterfall, rushing back again, leaving the creek dry as before. Sophia described the water as whimpering "hu! hu! hu!" as it swept round the edges of the shore. The tourists were afraid, and suggested going back, but the natives

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were anxious to finish the excursion, for there were nine visitors at nearly sixteen shillings a head, a sum that they did not wish to lose. The boatmen assured the tourists it was all right, urging them to get into the boat, when the party started on its way.

A Spectral Canoe.

"We pulled away about a mile and a half," Sophia relates, "when I looked round and saw a small canoe with one man in it come from under a pine. We thought it was someone trying to catch fish, and the men in the boat said, 'Look! There is someone going to catch *kouras*' (a species of freshwater crayfish); but, as we looked, the canoe got larger and shot out into the lake, and from one man the number increased to five. They were all paddling fast, fast, and to our horror they appeared to have dogs' heads on the bodies of men. Then the canoe got larger till it looked like a war canoe, and then we saw thirteen in it, all paddling faster and faster. Whilst we were watching, astonished and terrified—for the boatmen had stopped rowing—the canoe got smaller until only five men were left, and at last there remained but one very big man. The canoe got still smaller, and then, with the last remaining man, disappeared into the waters of the lake."

After seeing this the tourists became very much alarmed, feeling sure that the spectre canoe was a warning of some terrible event about to take place, but Sophia exclaimed, "What! you come all this way to see the Pink and White Terraces, and want to go back without visiting them. No, no, it is all right. See, we will go on." She then guided the visitors round the White Terraces, where they had lunch before going on to the Pink Terraces. Here Sophia saw the old Maori chief, Raugihena, telling him of the rising waters, and the apparition of the war canoe with the thirteen men paddling. The old man was sitting at his door with his arms folded, and he asked if she was telling a true story. "Yes," replied Sophia, "everyone in the boat, including the nine tourists, saw it."

"Then," said he, "if that be true, there is going to be a big war, and many chiefs and people will be killed. Alas!" The old chief perished afterwards in the eruption, for he went with his family to one of the islands on the lake; and whilst there the island was overwhelmed, and every living thing destroyed.

Six days after the warning Sophia guided a party of tourists to the Terrace as usual; and, among the sights, they visited a geyser which was sending out flames and smoke—a most unusual occurrence. This was on Thursday, June 9th. The water was very high in the lake; and, on returning to Rotomahana Hotel, Sophia told the proprietor what she had seen. He ignored her warning, telling her that she must prepare to take a party to Rotomahana for a fortnight.

"Well, well," Sophia replied, "never mind." But her warning was verified that very night. To quote her own words: "I finished my work at 11 p.m., and went to bed. But I had only lain down about five minutes when I felt the earthquake coming, heaving up the ground like waves. My old man went out and called to me, 'Sophia! the water is running down the hills.' I asked: 'Is it raining?' and he said, 'No.'

"Then I went out myself and heard it running down the hills. Then I went to my two old aunties, and asked them, 'What is this?' for the earth was shaking and heaving; but they said it was all right, and would soon be over. But I was frightened, and said to the old aunties, 'Come, we will go up to my wharé,' and just then the ground swayed up and down like waves, and the booming commenced like big guns going off and rolling like thunder.

"I was terrified, and went quickly down to get the children, and took them to my wharé, where I found ten or twelve people already. At half-past twelve the noise seemed to get louder, the thundering and booming with explosions, and a continuous vibrating sound like 'hm! hm! hm!' It was as light as day; yes, almost like the sun that is now shining on us. The light came from the crater. Then an appalling crash, and my old man said to me, 'Come and see; the world is going to be burnt!'

"It was a grand and awful sight. Tarawera in flames, rising high into the sky, the red-hot stones and lava pouring down its sides, the beautiful lake glowing in the blaze of light, all bright like noonday, and the surrounding bush nearest the mountain in flames. A great wind, too, came rushing down the Wairoa Valley towards the eruption, and so the splendid forest was blown down and quite destroyed. At half-past one a big black cloud came over Tarawera, settling over it, black as the darkest night; and there we sat in my wharé waiting, as we thought, for the last moment to come.

"We could hear the people come crawling along the little pathway, groping their way up the hill, for they could not see, and were only able to feel their way along. There was not a ray of light, only the blackest darkness, such as I had never seen before or since. At last there were sixty-two people huddled in the wharé. Whilst we were sitting there the red-hot stones and ashes began to fall, and under their weight the roof nearly gave way, so my old man and some of the younger ones got some wood and propped up the roof and walls, though fortunately the wharé was very strong and well built.

"The noise never ceased, and the terrible roaring was continuous. Then came the earthquake, and Rotomahana, another part of the mountain, exploded between half-past two and half-past three. All the people in the wharé were terrified. They wanted to rush out, but I would not let them go, saying, 'No, you shall not go. If you do, you

FIGURE 174. White Terrace, Rotomahana.

FIGURE 175. Middle Section, Pink Terrace.

(By kind permission of the Government Tourist Department of New Zealand.)

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FIGURE 176. Boiling Water, Lake Rotomahana.

FIGURE 177. Mt. Tarawera and Lake Rotomahana.

(By kind permission of the Government Tourist Department of New Zealand.)

will be killed. You must stay here, where at least we can all die together.'

"All through that awful night many were praying, each in his own way. At eight o'clock it was lighter, and an hour later we went outside, walking on the hot ashes and flint stones. As we went by the Green Lake, we met many who were crying bitterly, for their children or friends had been killed by the falling stones. Young Mr. Bainbridge, an Englishman, was killed by the falling of M'Crae's hotel. As we reached the Blue Lake, we were met by friends from Rotorua, who came to look for us, and were delighted to find we were safe after this night of awful horror—a night so dreadful it will live in my heart for ever."

Poor old Sophia is dead, but the story of her heroic efforts to save people on the dread night of the Tarawera eruption is revived again and again for the tourists who visit Te Wairoa.

Leaving Rotorua at a quarter-past eight on the morning of June 15th, 1913, our carriage passed along a winding road, skirted by fern-covered, low hills, and beside the shores of two pretty lakes, popularly known as the Blue and Green Lakes, to Te Wairoa, Sophia's home. It is a beautiful spot, shaded with leafy foliage, but deserted and silent as the grave. Walking along a path leading to the buried village, we saw the wheels of a waggon half buried in the mud, the ruins of the hotel, and a fowlhouse where two little children sought for shelter and were saved. Finally, we came to Sophia's wharé, within which so many escaped with their lives. Then, continuing on our way down a narrow path leading to a cottage, we stopped for a few moments and enjoyed a cup of tea.

Inside the cottage were relics of the tragedy, such as a hat whitened with pumice dust, petrified ham, a bottle of preserves, wedgwood china, a chandelier caked with volcanic dust, and a child's toy lamb, a sad memento of the little one so suddenly hushed to rest. Three or four little girls, dressed in white, were playing with their dolls outside the cottage; and their merry laughter, sounding through the ideal sylvan glade where the bright sunlight filtered through the leaves of the trees, enlivened the scene, making one wonder at the contrast between this peaceful scene and the tragic events of years ago.

SOLAR DISTURBANCES DURING MAY, 1915.

By FRANK C. DENNETT.

THE Sun was observed every day during May, with the exception of the 17th. Only faculae were recorded between May 11th and 19th inclusive, but spots were visible on all other days. The central meridian at noon on May 1st was 309° 21′.

Nos. 50, 51, 52, and 53 continued visible until May 8th, 8th, 9th, and 10th respectively, and therefore reäppear on the present chart.

No. 54*a*.—A group of pores broke out in the faculic remains of No. 54, and was visible on May 2nd, near the western limb.

No. 55.—On the 2nd a curved line of pores was visible, the leader being twelve thousand miles across next day. On the 4th the leader contained two umbrae, and the trailer three. On the 5th the latter had broken into pores; it was last seen close to the limb on the 7th. Its length was fifty-seven thousand miles.

No. 56.—An outbreak of pores south of No. 51 only recorded on the 2nd.

No. 57.—On the 6th a pair of pores had developed close to the central meridian in south latitude. On the 7th it had reached its maximum length, fifty thousand miles, with thirteen members. Last seen on the 8th.

No. 58.—First seen as a spot with a small companion, close to the north-eastern limb on May 6th the spot continuing until the 9th.

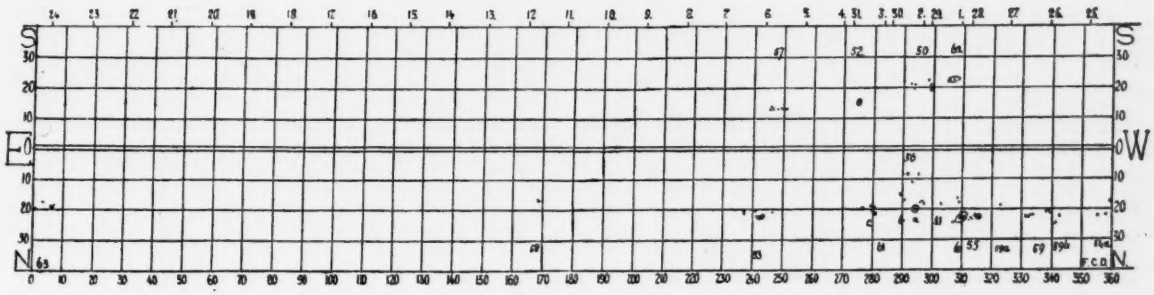
No. 59.—A group fifty-seven thousand miles in length, and its largest member fifteen thousand miles in diameter, seen from the 20th to the 30th, a little ahead of the larger disturbance, and varied much in appearance.

No. 59*a*.—A pore, following No. 59, seen May 24th to 26th.

No. 59*b*.—On the 29th a pair of pores showed north-west of No. 59, but were not seen after.

No. 60.—A group of considerable spots came into view within the north-eastern limb on May 21st, covering the area of the large trailer of No. 55. The large spots had a maximum diameter of twenty-two thousand miles, and the disturbance was seventy-one thousand miles in length.

DAY OF MAY, 1915.



The appearance varied greatly; the umbra of the large spot had broken into three on the 28th; it appeared dwindling rapidly when last seen on June 3rd. The position of the main outbreak is shown by a dot-surrounded area on the diagram.

No. 61.—A spot, some eleven thousand miles in diameter, came into view on May 24th, and continued visible until June 4th; on the 28th and 29th it was accompanied by a pore.

No. 62.—Some minute pores were seen on the 24th only, in a faculic area within the south-eastern limb.

No. 63.—A spotlet and pores forming a group fifty-seven thousand miles in length, approaching the north-western limb, seen from the 28th until the 30th.

Faculae were recorded within the north-western limb on May 2nd, 3rd, 9th to 12th, 15th, 18th, 19th, and 31st; north-east on 2nd, 3rd, 5th, 10th, 11th, 13th, 18th, 19th, and 25th to 31st; east on 13th and 19th; south-west on 1st, 3rd, 7th, 8th, 10th to 12th, 18th, 19th, and 24th to 29th; and south-east 1st to 3rd, 8th to 10th, 13th to 16th, 18th, 19th, and 21st to 27th.

Our chart is constructed from the joint observations of Messrs. J. McHarg, E. E. Peacock, R. H. Marchment, W. J. Waters, and F. C. Dennett.

CORRESPONDENCE.

GERMAN *V* BRITISH SCIENCE.

To the Editors of " KNOWLEDGE."

SIRS,—The comparative estimation of national genius is perhaps a somewhat vain occupation; nevertheless, one is tempted to follow in the footsteps of so distinguished a person as Professor J. A. Thomson, especially when such a gentleman takes the lead against the prevailing expression of opinion.

I was much interested in the three-country list in the May number of "KNOWLEDGE," but could not help feeling that a comparative table which contained in the German column the name of Kepler, but omitted Newton from the British list, was something of a curiosity.

Furthermore, whilst in the article Professor Thomson quotes a hypothetical question suggesting the futility of comparison between German and British geologists, I find no single exponent of that science in the British list. Surely at least two of Professor Thomson's countrymen are worthy of a place in it.

Again, the Professor's high opinion of George Green invites recollection of John Couch Adams; and the absence of the names of Cavendish and Priestley from a list that includes Graham can hardly be counted representative.

I think that it will generally be accorded that Alfred Russel Wallace (with all his failings) deserves to be bracketed with Johannes Müller.

The fact that the population of Germany exceeds that of this country by about fifty per cent. must also, I think, be taken into account in an absolute comparison of numbers.

I am curious to know what the French will say to the substitution of Bergson for Comte. Huxley's opinion of the latter may have been just; so may French opinions of Spencer.

I think Professor Thomson had better try again, or, better still, give us a list of the great ideas which have transformed thought or action, such as the doctrines of Gravitation, Conservation of Energy, Natural Selection, the Atomic Theory, the Steam Engine, Steam Navigation, Telegraphs, Railways, or Printing (lonely achievement!), with the names of the nations which gave them birth. These are the things that count.

A. J. H.

ABERYSTWYTH.

[Not for a moment did I suppose that I was telling the whole truth when, in my short article, I called attention to part of the debt that science owes to German investigators—a debt which there has been a recent tendency to disown. I was protesting mildly, in the interests of accuracy and fair play, against swinging from an extreme of deference to an extreme of disparagement. My critic is within his rights in keeping to the document before him, but if he had found opportunity to read the longer essay to which I referred, he would have found that I shared his appreciation of Newton, Adams, Cavendish, Priestley, and Wallace, as well as the view, to which I have been led by the testimony of experts, that the British contributions to geology and natural philosophy have been of greater eminence than those made in Germany. In the same essay I have given some indication of the great generalisations, such as the cell theory and the continuity of the germ-plasm, which have been substantiated by German investigators. As to the principle of the conservation of energy, for instance, we must not forget men like Mohr, Helmholtz, and Clausius in remembering men like Colding, Joule, and Thomson. That was my whole point. As to the substitution of Bergson for Comte, I did not suggest it; but in the minds of many it has come about.

J. A. T.]

JUNE METEORS.

By W. F. DENNING, F.R.A.S.

In June, 1914, meteors were rather abundant, and a number of fireballs was well observed.

But in the present month meteors have been unusually scarce. Watching on nine nights between 1st and 17th, I saw only twenty-five meteors in observations covering seventeen hours.

In past years I have generally been able to discern six meteors per hour on a clear, moonless June night. In 1887 the weather was magnificent, and I observed one hundred and ninety-six meteors in forty-two hours' observations during June. Allowing for time spent in registering the apparent paths, this would be an equivalent to an hourly number of six.

Mrs. Fiammetta Wilson at Bexley Heath, Miss A. Grace Cook at Stowmarket, the Rev. M. Davidson in Essex, and other observers have also noticed the remarkable scarcity of midsummer meteors this year.

Possibly there are annual variations in the number of meteors visible, and I have seen what appears to be undoubted evidence of this; but my results were not regularly maintained during a large number of years, so I cannot determine the extent of the variation or its period.

I certainly believe that in ordinary years, meteoric activity is a little greater during the second half than during the first half of June; but moonlight interferes this year, so we cannot ascertain whether the last fortnight of the month will offer any compensation for the almost meteorless skies of the first half.

Sometimes I have recognised a rather rich shower of streaking meteors from a radiant at 312°+61°, and this bears a suggestive accordance with the date and radiant of Comet I, 1850, viz., June 23rd, 313½°+60½°. But I have detected nothing of the possible cometary shower this year up to the time of writing. It may be merely an accidental agreement, for there are showers from near α Cephei at many times of the year.

The great annual increase in meteoric phenomena usually takes place, at the middle of July, with the coming of the Perseids, and it endures until the middle of December, when the Geminids are leaving the sky.

PHOTOGRAPHS OF THE MOON.

From a photograph by Philip E. Belas. *Crawford Observatory, University College, Cork.*

FIGURE 178.

The Moon, 22nd February, 1915. Age 8·6 days.

Refractor: Aperture, 13-in.; F.L., 11-ft.; Expos., ½-sec.

As seen in an inverting telescope.

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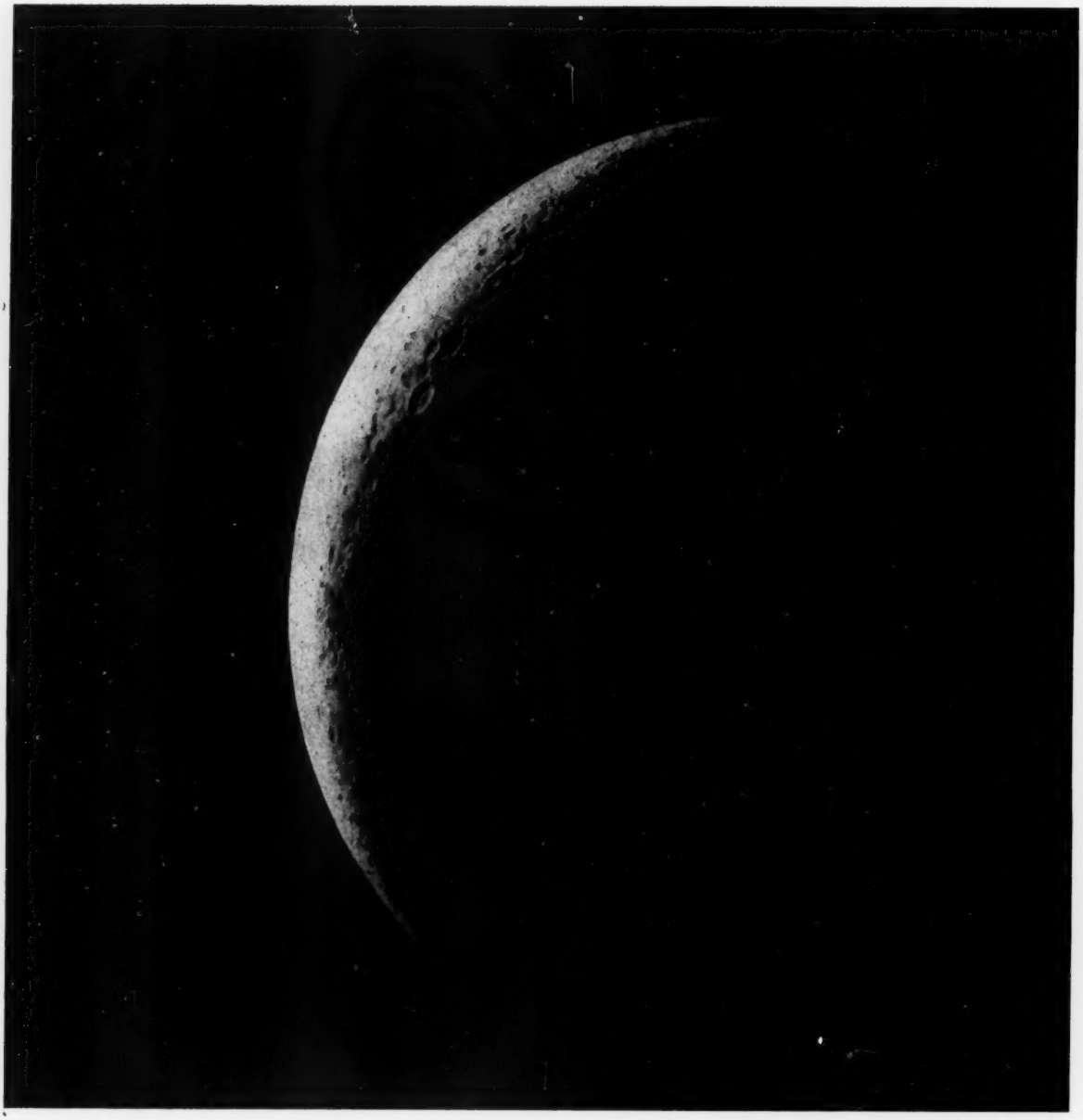
PHOTOGRAPHS OF THE MOON.



From a photograph by Philip E. Eelas. *Crawford Observatory, University College, Cork.*

FIGURE 179.

The Moon, 18th January, 1915. Age 3·1 days.

Refractor: Aperture, 13-in.; F.L., 11-ft.; Expos., $\frac{1}{2}$-sec.

As seen in an inverting telescope.

THE GRAPHICS OF GRAVITATION.

By PROFESSOR A. W. BICKERTON, A.R.S.M.

Introduction.

Although the following system of graphics was chiefly worked out some thirty-five years ago, and has often been used in lectures, it has not been published. It was largely used to solve the problems involved in the cyclic cosmology of impact.

The oblique impacts and interpenetration of cosmic bodies and systems have interested many able scientific men. Amongst the chief workers may be mentioned Johnston-Stoney, Kelvin, Ball, Arrhenius, and See.

In 1878 the writer was trying to solve the problem of novae, and made the induction that they were third stars struck from grazing suns; he saw that the problem of oblique collision would have to be divided and studied in two sections. Up to that time the idea had been that the graze of two dead suns would clothe each in shining fluid. It was seen that the stupendous velocity acquired by attraction would cause the two suns to cut one another, the parts actually meeting, coalescing to form a third body, whilst the wounded remainders would pass on in space. As it were, stellar flint and steel had struck and produced a stupendous cosmic spark.

To emphasise the idea, the phenomenon was called "partial impact," and the induction, the theory of the third body. This idea of the formation of the new third explosive sun when once studied is not disputed. The physical facts deduced agree absolutely with the complex light-curve and series of spectrograms of novae, whilst other impact theories that have been studied by astronomers do not do so. Consequently the idea of novae originating in impact of stars had been largely given up. Astronomers also now argue that on grounds of probability there could not be so many stellar impacts as there are novae, but this argument is quite fallacious, as there are probably scores of thousands more impacts brought about by fully a dozen agencies than there would be mere random encounters of stars; hence we must look upon the collision of suns as a definite *vera causa*, whatever view we may take of the resulting phenomena.

Several very able mathematicians became interested in partial impact; but it was soon seen that the problems involved were exceedingly complex, and far beyond the range of our present analytical methods. On the other hand, the facts of observation of every problem were somewhat vague, so that it was soon seen that graphics would be more than sufficiently accurate for the purposes of the investigation. Beverley, the analytical mathematician, who was so interested in science that he endowed the New Zealand University with some £80,000, was well versed in graphics, and helped much in the earlier problems. It was found that graphics were more powerful in solving the problems than analytics. Soon, however, some of these problems got outside of the graphic means then available, and it was some years before the more difficult problems were solved. The gravitation graphic of time was one that proved very elusive. But, by interposing a curve of duration after that of velocity, the curve of time was at length obtained.

As a rule, there were many variable factors in most of the problems. The method of taking one variable at a time was used, and this enabled most of the problems to be solved.

Thus, in the graphics of the energy of the formation of a sun from a nebula, by using a constant density in the growing sun, the problem was facilitated; it was made still easier when a constant volume was used. This idea of allotting a definite portion of space to the growing sun and varying the density was the mode that enabled most of the difficult problems to be solved.

The new chemico-physical theory of stellar structure and evolution, that looks upon the stars as consisting of a dense nucleus below the photosphere and an ensphering shell of light gases surrounding it, has enabled a number of other problems to be solved, until now there is scarcely a stellar spectrogram but has a rational physical explanation.

The Laws of Gravitation.

Newton, by the pellucid clearness of his geometric and dynamic mind, was able to take the complex facts so laboriously got together by Kepler, Galileo, and Hooke, and weave the whole into the exquisitely beautiful fabric of the "Principia." The woof and warp were the two simple and almost obvious laws that bodies attract in proportion to the product of their masses, and inversely as the square of the distances of their centres of gravity. To take two concrete examples, treble the mass of each and the pull is nine times as great; or treble the distances of their centres of gravity and their pull is one-ninth.

There is a very remarkable fact about the nature of gravitation that is not true of other forces. Matter has the property called "inertia." The name implies the fact that bodies at rest remain at rest, and bodies in motion remain in steady motion in

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the same straight line, unless acted upon by a force, forces being pulls, pushes, or twists. The amount of the inertia of matter is proportional to the mass; so, in any one place, is the gravitational attraction. The cause of this extraordinary dual property of matter is a profound mystery: only the crudest of guesses have ever been given to explain it. We shall have much to say on the phenomena that result from this important and basic dual fact of nature. We will first try by diagrams to understand what are known as the two laws of gravitation.

LAWS OF ATTRACTION.

Suppose two unit mass particles of matter to be at unit distance; call the attraction 1 (see Figure 180*a*). Then, if we double the mass of one, it will pull twice as strongly (see Figure 180*b*). If we now double the other, the new particle will pull each of the other units; hence the total pull is 4 (see Figure 180*c*). Again, add 1 to each side, and we have 3 on each side pulling each of the 3 on the other side; that is, the pull is 9 (see Figure 180*d*). In each case the pull is the product of the masses. But notice another thing. Think of the three cases as suns or other cosmic bodies at similar distances. The pull of a pair of unit mass suns is, say, 1; of suns of two unit mass, 4; of three unit mass, 9; and of ten unit mass, 100. That is, the pull exercised by pairs of similar suns, when the constituents of the pairs are at the same distances, is as the square of their mass. Hence also, if they are of the same volume, but differing in density, the energy of collision developed by equal distances of fall will be as the square of their mass. Hence, if we have two suns of equal mass formed by collision, and one has been formed by the complete collision suns of small mass, and the other by having a tenth grazed off from two suns of the same volume and of ten times the density, then this latter new third sun will have developed by the collision ten times the thermal energy of the sun of the same mass formed by complete coalescence.

Hence, as we know that the gravitation energy of fall from stellar distances is just about one-half that necessary to make a diffused nebula, in the case of the above sun, formed by a graze, the energy will be five times that required to make a nebula. The extraordinary results that follow this abnormal quantity of energy were debated in part in Volume XXXIV of "KNOWLEDGE" (see pages 362–367, 379–383, 413–418, and 453–459), and more fully in "The Birth of Worlds and Systems" in Harper's Library of Living Thought; in "The Romance of the Heavens" and elsewhere. This important fact is an example of a principle called "augmented energy."

THE LAW OF INVERSE SQUARES.

The surfaces of spheres vary as the square of their radii. If we take three concentric spheres of radii 1, 2, and 3, the surfaces will vary as 1^2, 2^2, and 3^2. Hence, if a light be in the centre and they are clear glass, the light that goes through unit surface of the first sphere will be spread over four units of surface of the second, and over nine units of surface of the third (see Figure 181). What is true of light is true of gravitation. Figure 183 represents the graphic of inverse squares. At distances $\frac{1}{2}$, 1, 2, 3, and 4 the intensities are 4, 1, $\frac{1}{4}$, $\frac{1}{9}$, and $\frac{1}{16}$ respectively. The laws of gravitation are the simplest and most fundamental of any of the forces in nature. The graphics of gravitation are also fundamental to most of the graphics of the other forces. The character of other forces are exceedingly diverse; thus we have in electricity and in magnetism, both repulsive and attractive forces. In both these forces the attraction may either be inherent or induced; in magnetism the forces may also be of a twisting character, and polar. It is constant when we are dealing with the magnetism of hard steel, and induced when we deal with the magnetism of iron. Forces may act on the whole mass as gravity does. Molecular attraction, that makes gases into liquids, acts on the whole molecule. Some forces only act in certain localities or in certain given directions, as in cohesion that locks liquids into solids, or as the attraction of unlike poles in magnetism. These we call "polar forces." The attraction between atoms we call "affinity." This is very strong when atoms are very unlike. This heteratomic attraction we call "chemical affinity." The attraction is also very strong with similar atoms; we then call it "isoätomic affinity": this attraction locks similar atoms into molecules. In common oxygen we have diatomic molecules; in ozone, triatomic. Chemical affinities are stupendously strong at infinitesimal distances, but are limited to very short distances. These forces are probably both polar and inductive. Gravitational attraction between isolated atoms is very minute, but it acts throughout the depths of space, and is cumulative; so that the potential energy of gravitation is probably the greatest energy of nature.

THE GRAVITATION GRAPHICS OF UNIFORM ACCELERATION OR THE LAWS OF FALLING BODIES.

A body falling directly downwards does so at such a great speed that it is difficult to determine its laws. There are several ways of lessening the direct effect of the gravitation of the Earth so that we are able to study its effect. One is by placing different weights on pivoted arms of equal length, or on the ends of a string on a free wheel. This arrangement is called "Atwood's machine." Another mode is by allowing smooth balls to roll down inclined planes. The graphics of these methods are the same. We shall use inclined planes as being the simplest mode of reducing the effect of the force of gravity.

A very effective mode of teaching the laws of falling bodies is to allow marbles to roll down

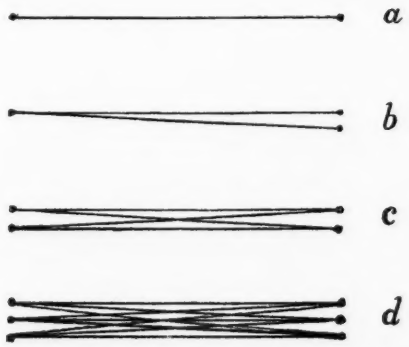

FIGURE 180. The dots represent particles of unit mass. The lines represent units of attraction.

a. 1 particle attracts 1 with the force of 1.
b. 2 particles attract 1 with a force of 2.
c. 2 particles attract 2 with force of 4.
d. 3 particles attract 3 with force of 9.

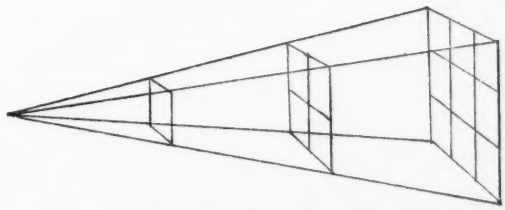

FIGURE 181. At one unit distance from a source of light, the area covered is one and intensity one. At two units distance, the area covered is four and intensity is a quarter. At three units distance the area is nine, and the intensity one-ninth. This is also the law of gravitation.

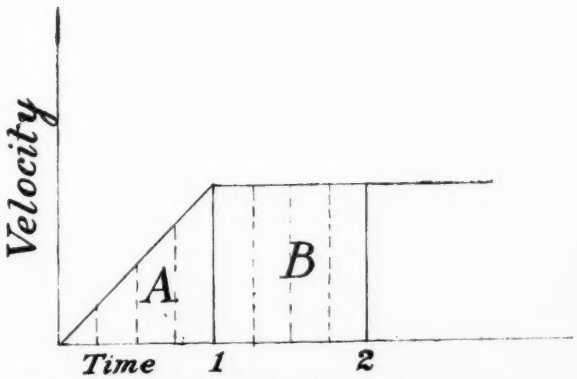

FIGURE 182. Graph of Acceleration and Constant Speed.—The vertical dotted lines represent speed at each quarter of a unit of time. The area A represents the fall down the inclined plane, the rectangle B the steady roll.

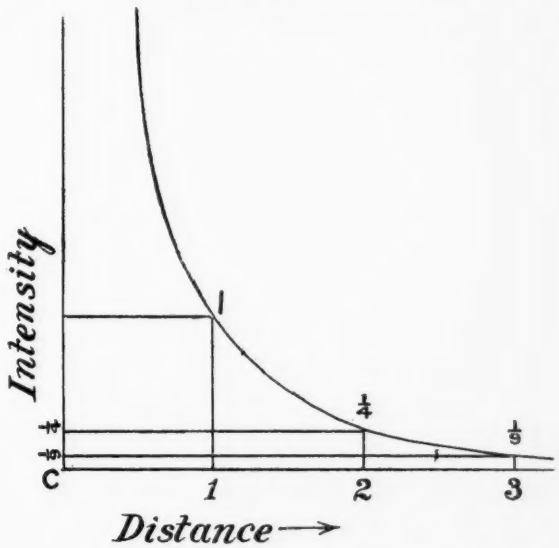

FIGURE 183. Graph of Inverse Squares.—C centre of sphere. The vertical lines represent intensities inversely as the square of distance.

FIGURE 184 shows that a light and a heavy marble rolling down an inclined plane gain speed at the same rate, except that the air resistance is slightly smaller in proportion on the large marble.

FIGURE 185. Table for inclined plane experiments. The marble *a* has been released and has rolled down. The marble *b* is now released and reaches the bottom when *a* reaches the box.

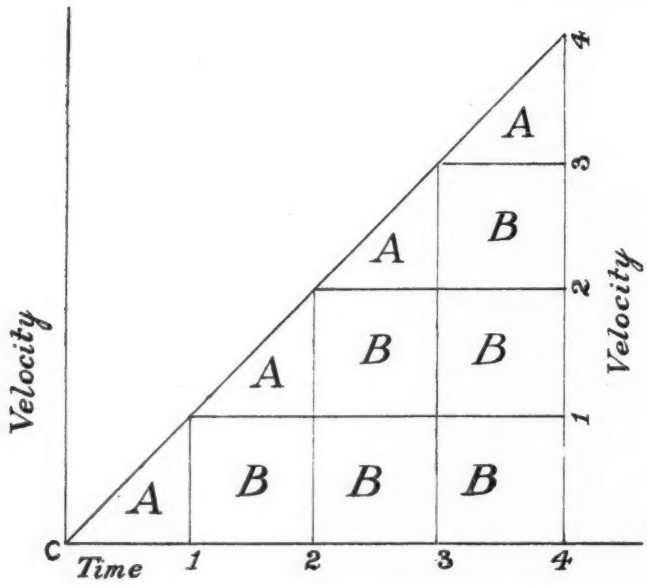

FIGURE 186. The Graph of Time and Velocity.
The triangles A are the distance travelled, due to acceleration. The rectangles B are distances travelled, due to velocity already acquired, in consecutive units of time. The distances are respectively $\frac{1}{2}$, $1\frac{1}{2}$, $2\frac{1}{2}$, $3\frac{1}{2}$, total 8.

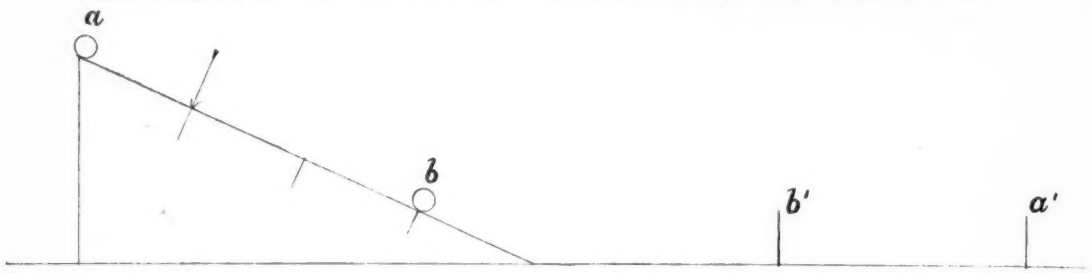

FIGURE 187. *a* is liberated; then when *a* reaches the arrow, *b* is released. They reach the bottom together, *a* moving with double the speed of *b*. They strike the obstacles together. This shows it requires four times the work to double the speed.

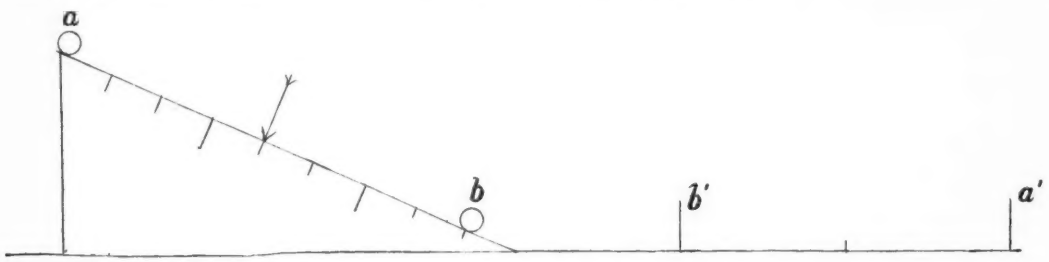

FIGURE 188. *a* is released; when it reaches the arrow, *b* is released. They reach the bottom together, and *a* travels three times as fast as *b*. They reach the obstacles together. The kinetol is 1 to 9, or K is proportional to V^2. See the first three units of time in graph, Figure 186.

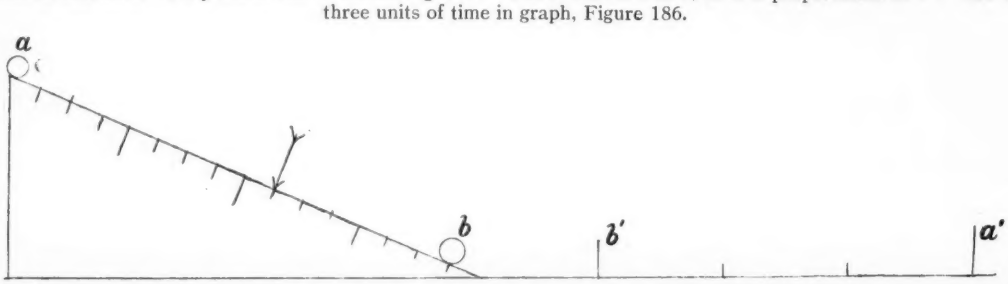

FIGURE 189. Same as Figure 188, only using four units of time of graph, Figure 186. Kinetol 16 to 1, time 4 to 1, velocity 4 to 1.

slightly tilted stiff laths of wood about four feet long, with a shallow V-shaped groove in them. In fact, this apparatus may also be used for teaching most of the laws of dynamics in general. In this article we shall only describe their use in illustrating the graphics of gravitation.

To show inertia, have a lath with one end very slightly higher than the other; a marble is placed on the upper end. On lifting the finger from it, inertia causes it to seem to stand still for a time, and then it begins to roll down. It gathers speed as it travels, and when it reaches the table it ceases to gain velocity. The inertia of motion causes it to roll on the table until it is stopped by friction or an obstruction. If we increase the tilt, the ball runs down faster, as the resultant force of gravity is greater. The increase of speed in each unit of time is called "acceleration."

Let us now have two of the grooved laths, at the same slope, and put a small marble on one and a large one on the other, and release the two at once. The friction of the air acts slightly more effectively on the smaller marble, yet they practically roll at the same speed (see Figure 184). This is a simple way of repeating Galileo's famous experiment made by dropping a light and a heavy weight from the Leaning Tower of Pisa; an experiment that overthrew the doctrine of the Schoolmen that had been erroneously taught in all the seats of learning during the thousand years of the Dark Ages; an experiment that so prejudiced his colleagues against poor Galileo that he had to quit his professorship.

The mass multiplied by the speed is called "the momentum," and by multiplying the mass by the distance the mass has fallen in gaining the speed, and by the intensity of the force, the resultant is called "the energy" or "the work."

Velocity is the distance a uniformly moving body will travel in unit time. Bodies moving at a uniform speed will travel, in a given time, distances proportional to the speed.

To show that a uniformly accelerated body in unit time gains twice the speed of the distance it has travelled, place two inclined laths side by side at the end of a long table. Place a tin box at the foot of one, and another box at twice the length of the lath away from the feet of the laths; place a marble (*a*) on the top of one, and another (*b*) on the top of the other lath. When *a* reaches its foot, as in diagram Figure 185, release *b*; the two marbles will strike the boxes together. This experiment shows that, whilst *b* is running down the slope and gaining speed, the marble *a* has travelled at a uniform speed twice the distance.

In these graphics of uniform acceleration the vertical distance is speed, and the horizontal distance time. The areas of the triangles and rectangles are the distances travelled. In the graphic, Figure 182, the triangle A represents the fall down the lath, and the rectangle B represents the roll on the table at uniform speed. The vertical dotted lines represent speeds at intervals of quarters of units of time.

It will be seen that, if we divide the time into infinitesimals, the marbles start from rest, gradually gain speed, and then travel in the rectangle at a constant speed; the triangle is equal to the rectangle divided diagonally into two equal parts.

The distance travelled on an inclined plane under the influence of unit force is half the final velocity squared, $\frac{V^2}{2}$, or half-time squared, $\frac{T^2}{2}$.

In one unit of time the marble will gain a unit of speed, and travel half a unit of distance, gaining a unit of acceleration. In another unit of time the marble will gain another unit of speed, and will travel one and a half units of distance. In the third unit of time it will gain another unit of speed, and pass over two and a half units of distance. In the fourth unit of time it will gain another unit, and have a speed of four units velocity, and will travel three and a half units of distance. That is, in each unit of time it gains a unit of increased speed; that is, the acceleration is unity and is constant. The speeds in succeeding units of time are 1, 2, 3, and 4; the distance travelled in the four successive units is $\frac{1}{2}$, $1\frac{1}{2}$, $2\frac{1}{2}$, $3\frac{1}{2}$. The sums we get if we add together and take the distance travelled in 1, 2, 3, 4 seconds respectively are $\frac{1}{2}+1\frac{1}{2}+2\frac{1}{2}+3\frac{1}{2}=8$, that is, $\frac{t^2}{2}$, or final $\frac{v^2}{2}$, shown in graphic, Figure 186. This is shown experimentally with rolling marbles by dividing one pair of laths into quarters and sixteenths, and another into thirds and ninths, and inclining the two laths equally side by side.

On the laths divided into quarters, place the marbles as seen in Figure 187. Lift the finger and release marble *a*; when it reaches the quarter with the arrow, release *b*; they will reach the bottom together, and *a* will travel at twice the speed of *b*, as is seen by their hitting the tin boxes placed at the respective distances at the same time.

This experiment illustrates by concrete example an immense number of principles. It shows that speed gained by a uniform force is proportional to time, and that as momentum is MV it is also time multiplied by force. It also shows that energy is $\frac{MV^2}{2}$, and also force multiplied by the space through which it acts. It shows that, with a constant force, velocity is proportional to time, and that velocity is proportional to energy squared. It shows that a body travels three times as far in the second unit of time as in the first, and it also shows many other dynamical facts.

The experiment may be repeated by using the laths divided into nine as in Figure 188. Release *a*, and when it reaches the arrow, release *b*. They reach the bottom together; and, if allowed to roll on the table, travel with speeds of 3 to 1, the fall being 9 to 1, as seen in diagram.

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Or take laths divided into sixteenths. Place marble *a* at the top of one lath, and marble *b* at one-sixteenth up the other, and release *a* (see Figure 189); then, when it reaches the arrow, release *b*. They reach the bottom together, and travel at speeds of 4 to 1, showing energy 16, velocity 4. But the many prolific examples possible must not detain us.

(To be continued.)

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

THE DYNAMICS OF THE STELLAR UNIVERSE.—In the textbooks of sixty years ago it was usual to give Mädler's speculation that the entire stellar universe was revolving round the Pleiades in a similar manner to the revolution of the planetary system round the Sun. The knowledge of the stellar motions was then very limited. The lapse of time has enormously increased the number of stars whose proper motions are known, and has shown that their movements do not conform to the type of the planetary ones, and cannot be explained by circular revolution round a common centre. The next step was the discovery of the Two Drifts of the stellar motions, which was originally taken to mean that two great clusters or clouds of stars were moving in opposite directions, and had met, and were interpenetrating, each other. It was taken for granted that motions that radiated from a point in the sky were really parallel, just as parallel meteor trails appear to radiate from a point. Professor Turner was, I think, the first to view these motions from another standpoint: he showed that the apparent motions would be satisfied by the theory that the stars were actually moving to or from a fixed point in the universe; in other words, that motions that had been taken as parallel were in reality convergent or divergent. He revived the idea of the stellar universe as a revolving system, but the centre of attraction was not taken to be a giant star, as Mädler thought, but simply the centre of gravity of all the components. Also the orbits were not supposed to resemble those of the planets, bur rather those of the comets, being of the nature of long ovals. On this view the Two Drifts simply consist of the stars that are moving towards the centre and those that are receding from it.

Sir John Herschel, in the "Outlines of Astronomy," gave a suggestion as to the manner in which equilibrium might be maintained in globular clusters. He started with the theorem that the attraction inside a sphere of uniform density varies as the direct distance from the centre. This easily follows from Newton's propositions, that a spherical shell exerts no attraction on a point inside it, but attracts an external point exactly as though its mass were concentrated at its centre. Then consider the case of a point inside the uniform sphere. All that part of the sphere that is more remote from the centre than the point exerts no attraction on it, and we may imagine it removed. The attraction of the remainder of the sphere on the point varies as its mass, and inversely as the square of the distance from the centre. Since the mass varies as the cube of the radius of the inner sphere, we get the law of the direct distance. Under this law of attraction the orbit of a particle is an ellipse, with its centre at the centre of attraction (note the difference from the law of inverse squares, in which the centre of attraction is the *focus* of the ellipse), and the period is the same whatever the size of the ellipse. We can realise the conditions by suspending a weight by a long string, displacing it from its lowest position, and then giving it a push. It will swing in an ellipse, and the period will be found to be independent of the size for moderate displacements.

Sir John Herschel showed that, if the stars in a globular cluster were scattered with tolerable uniformity, the attraction inside the cluster would vary as the distance from the centre, and consequently that the stars would all describe ellipses in the same time about the centre, provided that the orbits were so arranged that the uniform distribution and spherical form were approximately maintained. Professor Turner referred to this result, but pointed out that in the actual clusters the density is evidently not uniform, but increases considerably towards the centre. Under these conditions the orbits would no longer be ellipses, nor would the periods be all the same. However, the general character of the motion would not be much altered: the stars might still perform oscillations in long, narrow orbits of an oval type.

Professor Eddington examines the theory mathematically in *The Monthly Notices* for March, applying it, not merely to a single cluster, but to the whole stellar system. He makes the important simplification that the whole stellar system may be taken as spherical, and grouped about the centre in spherical layers, the density in each layer being constant. It is known that this is not true, the real shape being probably that of a bun whose thickness is about one-quarter of its breadth. But he begins with the simplest case, since even this offers considerable mathematical difficulties. Each star is subject to a force directed towards the centre of the system, arising from the combined attraction of the whole cluster. Disturbances of the motion of stars, due to the near approach of other stars, are shown to be very rare. One proof is the large number of stars that have been found to move along parallel paths with equal velocities. As these are separated by vast intervals, their disturbances by their neighbours would be different, and would destroy the parallelism of motion. The fact that this persists shows that such disturbances are inappreciable.

The velocity of any star is resolved into its radial and transverse components, and it is assumed that in the central region of the cluster these are equal, while, as we go further out, the transverse velocity becomes smaller and smaller compared with the other, so that at the outer surface the motion is almost entirely radial. We do not know from observation that this distribution of velocities holds throughout the cluster, but it is found to hold in our neighbourhood (it is merely another way of stating the Two Drift law), and we assume by analogy that it extends to the regions that we cannot as yet explore. There are not enough data to ascertain the distance from the Sun to the centre of the cluster, or the star-density in the central region. It seems clear that this density cannot be less than four times that in the Sun's neighbourhood, and may be as much as seven times. In the latter case the distance of the Sun from the centre is five hundred parsecs, or one thousand six hundred light-years. In falling through that distance to the centre, the Sun would acquire a velocity of thirty-six kilometres per second. The distance from the Sun to the centre must in any case be considerable, for otherwise the star-density in the region outside the Sun would fall off much more rapidly than observation indicates. Professor Eddington explains that the reason that the density at the centre is not still greater, with so many orbits passing through or near it, is that the speed of the stars at that region is at a maximum, and carries them quickly through it. He looks forward to extending his researches to a bun-shaped cluster, which may modify the numerical results considerably.

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Incidentally his work makes it improbable that the number of dark stars enormously exceeds that of the lucid ones, as was maintained in a paper that I referred to in this column.

It is, I think, interesting to compare the progress of stellar astronomy with that of planetary astronomy. The stage of simply finding the proper motions may be compared with the observations of the ancients on the apparent course of the Moon and planets, the detection of the Two Drifts with Kepler's detection of the laws of planetary motion. We have now reached the stage when the mutual gravitation of the stars is being considered, corresponding to Newton's discovery of the law of gravitation from study of the Moon's motion. We may surely hope that, just as planetary astronomy has made vast strides since Newton's time, so much will be made clear about the stellar motions which is still veiled in obscurity.

THE ALGOL SYSTEM.—Dr. Frank Schlesinger, in his address before the American Association for the Advancement of Science, suggests some astronomical problems that call for help from mathematicians: one of them is the rigorous investigation of the disturbances to which pairs of suns, revolving in close proximity, are liable. The Algol system is one of the best known of these. Many years ago Dr. Chandler concluded that there was a long-period inequality in the times of eclipse, suggesting revolution of the pair round a distant centre in a period of one hundred and thirty-one years. This explanation is still tenable, but is no longer held with great confidence, as it is recognised that there are other possible explanations. The revolution of the system round a third orb in a period of nearly two years is now confirmed. This was first announced by Belopolsky in 1906 from a study of the radial velocities, and Dr. Schlesinger now announces that he has confirmed it from analysing the eclipse times, which show an inequality amounting to five minutes which runs through its cycle in two years. It is now considered possible that the newly discovered companion may be the cause of the one hundred and thirty-one-year oscillation by a motion of the line of apsides or some other perturbative effect.

URANUS.—Professor Percival Lowell gives, in his *Bulletin*, No. 67, some measures of the oblateness of Uranus made by himself and Mr. Slipher. They obtain for the values at unit distance:

Equatorial diameter ...	36·166
Polar diameter (corrected)	33·009

The correction means the reduction from the apparent polar diameter to the true.

Assuming the accuracy of these figures, and combining them with their rotation period of ten and three-quarter hours, Professor Lowell concludes that the matter of Uranus is less concentrated to the centre than in the cases of Jupiter and Saturn, approaching more nearly to terrestrial conditions.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

MYRMECOPHILOUS PLANTS (" ANT-PLANTS ").—The statements that have found their way into many books regarding the adaptations of certain plants to a mutually beneficial partnership with ants have been largely disproved by more recent work. Two of Schimper's typical " myrmecophilous " plants have recently been reëxamined with this result. Escherlich (*Biol. Centralbl.*, Volume XXXI) finds that not only do the ants afford no protection to *Humboldtia laurifolia*, but they actually harm the plant by attracting woodpeckers, which eat the ants. He found, however, that ants collect and store the bulbs of another plant, a sedge (*Cyperus bulbosus*), and in this case may be of importance in the dispersal of this species. Miehe (*Abh. Sachs. Ges.*, Volume XXXII) has investigated *Myrmecodia tuberosa*, perhaps the most famous of the so-called myrmecophilous plants, and it would appear that the internal walls of the hollow tuber of this plant are in part smooth and yellow, and in part warty and black. In the latter areas ants deposit their excrements, whereas they deposit their eggs in the smooth areas. The black patches owe their colour to growths of fungi, which doubtless feed on the ant excrements; and since the tufts of the fungus were often seen to be shaved off, it seems possible that the ants use the fungi. The warty areas, however, develop independently of either ants or fungi, and appear to be essentially organs for the absorption of water. It would seem that in *Myrmecodia* the organisation of the tubers was related originally to water absorption and storage, the relation with ants being a secondary and incidental affair.

PROTONEMA OF THE MOSS *TETRAPHIS PELLUCIDA*.—As is well known, when the spore of a moss germinates, it does not at once give rise to a new leafy moss plant, but to a preliminary structure, or protonema, on which are developed buds, which produce moss plants. In most mosses this protonema is a filamentous body, consisting of branching rows of cells, but in a few cases it is a flat plate. Among these exceptional forms is *Tetraphis pellucida*, a moss fairly common, and chiefly growing on dead tree stumps. Hodgetts (*New Phytologist*, Volume XIV) describes a hitherto unrecorded case, in which *Tetraphis* plants, normal except that the tips of the shoots had died off or been injured, bore numerous flat tongue-shaped protonemal growths, each arising at the base of a leaf on the stem. In discussing this observation it is pointed out that flattened or thalloid protonema appears to be characteristic of, and practically confined to, those mosses which, for other reasons, are now usually placed low in the scale of classification, and also that it appears to be a general rule in both liverworts and mosses that the protonema formed vegetatively agrees in structure with that arising from the germinating spore.

CONJUGATION IN THE MOULD-FUNGUS *SPORODINIA GRANDIS*. — Miss Keene (*Ann. Bot.*, Volume XXVIII) has reïnvestigated the process of conjugation in the Zygomycete *Sporodinia grandis*, a mould growing on mushrooms and other large fungi, and has obtained interesting results. The general behaviour in conjugation is the same as in *Mucor*, the type of this group usually described in text-books, though *Sporodinia* is quite easily obtained, and is a more favourable type for the study of sexual reproduction, since the conjugating threads and zygospores are formed in the air, and not buried in the substratum. The nuclei of the two conjugating branches (gametangia) are small, and show the same structure, size, and staining reäctions as those of the mycelium. The wall between these branches is dissolved when the tips meet, and the gametes fuse, the protoplasm of the one flowing into that of the other; then nuclear fusions occur progressively, as the protoplasmic masses mix. Two sizes of nuclei result: large nuclei formed by fusion, and small ones which have failed to fuse; then the second wall of the zygospore is formed, and the unfused nuclei begin to degenerate. At about this stage there appear globular cytoplasmic structures, with which oil is associated, and which are apparently related to the elaioplasts, or oil-forming plastids present in many plants, serving to elaborate oil as a reserve food. These bodies fuse irregularly, and produce ultimately one or two large bodies saturated with oil; the resting zygospore also contains numerous nuclei, formed by fusion of the paired nuclei of the gametangia, the protoplasm being reduced to a thin layer surrounding the oil plastid.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON), F.I.C.

SERO-DIAGNOSIS OF PREGNANCY.—The method of determining the fact of pregnancy in its early stages by testing for the presence of an enzyme capable of hydrolysing placenta protein has already been described in these columns. This method has been investigated by Dr.

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McCord (*Coll. Papers Research Lab.*, Parke, Davis & Co., 1914, 425), who finds that the test is more accurate in the case of human subjects than of animals. With the former, control experiments give at most a faintly positive result, whereas the blood serum of non-pregnant animals may dialyse sufficiently to give a distinct reäction in the test. In systematic tests in two hundred and forty cases the result was never doubtful when applied to women, but stress is laid upon the point that the directions must be closely followed.

GLASS RESEARCH.—A Committee was appointed last October by the Institute of Chemistry to investigate the composition of glass for chemical purposes and to test the suitability of various formulae. The Council has now published a short report summarising the work of the Committee, and the results of its investigations have been placed at the disposal of glass manufacturers willing to make use of them.

It was found that the mixtures prepared in accordance with the analyses did not always prove satisfactory in practice, though analysis was helpful in suggesting variations. Up to the present, eleven formulas have been published, and in each case the suitability of these for working on a large scale has been tested. These include soft glass for ordinary laboratory use, a resistant glass for flasks, glass for combustion tubing of the type of Jena glass, for miner's lamp glasses, and soft soda glasses for tubing and for *x*-ray glasses.

The influence of the different constituents upon the properties of the glasses has also been studied, and in the Committee's opinion sufficient information has now been acquired for the manufacture of all the important glasses the supply of which has hitherto been chiefly derived from abroad. A full report of the experiments in this investigation is promised.

CHEMICAL ORGANISATION IN GERMANY.—A recent issue of the *Chemiker Zeitung* (1915, XXXIX, 251) gives some instructive details of the methods now adopted in Germany for the organisation of chemical industry for the purpose of the war. The control of all raw materials for war munitions has been assigned to a department of the War Office, while separate committees have charge of the methods of dealing with particular products, such as metals, chemicals, leather, cotton, linen, and so on. The supervision is carried out with the assistance of war companies established for the purpose (as, for example, Kriegschemikalien A.G.) and of clearing-houses for each of the raw materials. Similar steps have also been taken in Belgium for the effective utilisation of raw materials.

Great efforts have been made to ensure an increased output of ammonia and nitric acid (required for explosives), copper has been refined on an immensely increased scale, and a new industry for Germany has been started in the refining of zinc. The scarcity of certain metals has led to the adoption of various substitutes, and it is stated that tinplate has been employed successfully in place of aluminium, while steel and galvanised iron have taken the place of brass and copper alloys. Electrical conductors are now being made from iron.

MANUFACTURE OF BENZOL FROM PETROLEUM.—The Secretary of the Interior Department, United States, issued recently a general statement concerning a process of obtaining gasoline and benzol and toluol from crude petroleum. This process has been discovered in the State Laboratory by Dr. Rittman, and is to be patented in the name of the United States. Pending the issue of the patent, only general details are available; but from what is known it would seem that America should in the future be in a position to produce all the aromatic hydrocarbons required by the country for the manufacture of dyestuffs and explosives.

The principle of Rittman's process is to heat regulated quantities of vaporised petroleum oil in an iron tube at a specified temperature and pressure. For the production of gasoline (petrol) the vapours are heated to about 450° C., under a pressure of ninety pounds per square inch, while a temperature of about 500° C. and a pressure of one hundred pounds per square inch are necessary for the formation of benzol and toluol. The products of the autoreäction are condensed and withdrawn from the tube, leaving the gaseous components behind to continue the process; and it has been found that the greater the proportion of gases present, the larger the yield of liquid products. In laboratory experiments about eighty per cent. of a heavy petroleum oil distillation residue could be utilised, and by repeated passage through the iron tube yielded about eight per cent. of gasoline. In like manner a single passage of the vaporised oil through the tube at the higher temperature and pressure gave a yield of about six per cent. of benzol and toluol. It is anticipated that when the conditions suitable for working the process upon a commercial scale have been ascertained the quantity of these hydrocarbons to be obtained from petroleum oil will be from six to ten times as much as is now derived from coal-tar.

GEOGRAPHY.

By A. SCOTT, M.A., B.Sc.

ZONAL LAKE-BASINS IN THE ALPS.—In 1902 Preller (*Q.J.G.S.*, LVIII, page 450) expressed the opinion that the principal Swiss lake-basins were formed subsequently to the first (Pliocene) glaciation. Two years later the same author (*ibid.*, LX, page 65) adduced evidence to show that, in the case of the Lake of Zurich, the lowering of the valley-floor commenced during the final glaciation, and continued during the retreat of the ice. The evidence consisted mainly in the essentially fluviatile nature of certain deposits, hitherto considered glacial, the formation of these being now assigned to the second interglacial period. This view was later extended to other lakes, notably the Lake of Geneva, where he ascribed the formation of the deep basins to flexuring of the Molasse (Flysch). He further demonstrated that the chief basins in sub-Alpine Switzerland lie in a zone parallel to the Alps, and entirely in the Molasse formation; now further evidence in favour of these conclusions is brought forward (*Geol. Mag.*, May, 1915).

If any lakes existed prior to the last glaciation, these must certainly have been rapidly filled up, since the interglacial deposits are strictly fluviatile. Heim's view, that the lakes were preserved by the deposition of moraines, is untenable, as the rivers, which traversed the basins, must have flowed at an altitude much above the present valley-floors (the Lake of Geneva has been lowered one hundred and fifty feet since the retreat of the ice), while, in addition, there is no evidence of any preglacial or interglacial basins. The great depth of the central portions of the lakes cannot be explained by glacial erosion, but arises through the slow subsidence of the lake-floors, due to the zonal bending of the Molasse, the deepest parts lying in the "maximum of syncline."

PLANE-TABLE TRIANGULATION FROM ONE STATION.—In plane-table work the moving of the table from one end of the base-line to the other is often troublesome, but E. A. Reeves has now devised a method which obviates this difficulty (*Geog. Jour.*, May, 1915). Either a known point on the map is taken as the other end of the base-line, or the distance of an unknown point is determined by means of a distance-finder alidade and this point taken. The problem then is to draw on the map a line parallel to a line joining two distant points, the position of one of which is unknown. This can be done by means of an attachment, consisting essentially of a light frame carrying a number of horizontal wires and fixed to the telescope of the alidade. An arc to measure vertical angles is also attached. From an assumed value of the distance of the unknown point, the angle which the latter subtends at the other end of the

base can be calculated. This angle is set on the arc, and the frame turned about a vertical axis till the two points coincide with one of the horizontal wires. A line on the plane-table parallel to this wire gives the required direction. The method can be used for distances up to ten miles, and its accuracy compares favourably with that of other graphical methods, the error, in an observed case, in a distance of seven thousand five hundred yards being forty-five yards, or 0·6 per cent.

GLACIATION OF STRATH SPEY.—An exceedingly interesting set of glacial phenomena is displayed in the valley of the Spey, and four well-defined stages have been recognised by the Geological Survey (*Geology of Mid-Strath Spey*, 1915). The earliest is the period of maximum glaciation, during which the whole area seems to have been covered by an ice-sheet, which originated far to the west, in the mountainous region north of Rannoch Moor, and had a general eastward trend. Direct evidence of this glaciation is somewhat difficult to obtain owing to the disintegration of the granite in the higher districts, and to the effect of subsequent ice-action at lower levels. The numerous boulders of the hornblende granite of Rannoch Moor, found in the Upper Spey, were probably transported by the later confluent glaciers which mark the second stage, as they are not found on the higher ground. These confluent glaciers seem to have arisen in two independent centres, the one being that mentioned above, and the other the high plateau of the Cairngorms. While the confluence is difficult to locate, it probably lay for a time on the eastern borders of the forest of Glen Feshie. Below the junction the two ice-streams flowed in a northerly direction, and possibly coalesced with another ice-stream flowing out of the Great Glen. The third stage was initiated when the high ground became free of ice, and independent glaciers came down the valleys of the Findhorn, Spey, Dulnain, and so forth. These valleys are characterised by a striking series of retreat phenomena, including glacial lakes, overflow channels, cutting across the drainage directions, marginal terraces, lateral and terminal moraines, and numerous fluvio-glacial deposits. The last stage is represented by the high-level corrie glaciers, with well-defined moraines in many of the cirques, and occasionally moraine-dammed lakes. Loch Coire an Lochan, which occurs at a height of three thousand two hundred and fifty feet on Braeriach, is a very fine example of the latter.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

THE SHAPE OF PEBBLES.—It has been alleged that pebbles have distinctive shapes or marks according to whether they are of fluviatile, marine, glacial, or aeolian origin; and they have been used as criteria to determine the mode of origin of the sediments in which they occur. Professor H. E. Gregory, however, throws much doubt upon these criteria (*American Journal of Science*, March, 1915). It has been assumed by various observers that flat and wedge-shaped pebbles are characteristic of river-deposits; that pebbles of marine origin are well rounded, oval, or roller-shaped; that polished pebbles of characteristic "Dreikanter" form indicate desert origin; and that glaciated pebbles are polished, striated, and faceted in a characteristic fashion. Professor Gregory shows, however, that these shapes are by no means always produced by the respective agents. Flat or wedge-shaped pebbles are frequently found on beaches, and rivers often produce perfectly rounded shapes. The shapes of pebbles on beaches (and in rivers) are frequently controlled by their original forms. Glacial and river pebbles, along with freshly broken material, are contributed by erosion to both beach and river. "Round and oval fragments tend to retain those shapes; blocks with rectangular and square cross-sections develop elliptical or circular cross-sections; flat fragments tend to remain flat or to become discoid. If the material supplied to waves consisted of silver dollars and marbles, it is difficult to imagine how any pebbles other than flat or round could result from the most vigorous and long-lived wave-abrasion." It is also pointed out that typical glacial pebbles are really rare. Professor Gregory says that "pebbles and boulders which may be unqualifiedly assigned to ice-work do not exceed one in a thousand of the Connecticut glacial deposits."

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.Met.Soc.

THE WEATHER OF JULY.—Of all the months of the year July is the warmest. The winds are generally from the westward, but in very hot seasons an easterly current may sometimes prevail for a few days, and eventually result in severe thunderstorms. St. Swithin's Day, the 15th, is popularly looked upon as a critical day for determining the weather for the next five or six weeks. The old proverb is:—

> "St. Swithin's Day, if thou dost rain,
> For forty days it will remain:
> St. Swithin's Day, if thou be fair,
> For forty days 'twill rain nae mair."

July was a very hot month in the years 1852, 1859, 1870, 1876, 1887, 1900, 1905, and 1911. It was cold in the years 1841, 1860, 1879, 1888, 1892, 1907, and 1910.

The average mean temperature at Greenwich for July is 62°·7; in 1859 it was as high as 68°·9, while in 1841 it was as low as 57°·7. The average maximum temperature is 74°·2; the highest mean was 82°·0 in 1868, and the lowest 67°·2 in 1879 and 1888. The average minimum temperature is 53°·3; the highest mean was 57°·2 in 1859, and the lowest 49°·4 in 1863. The absolute highest temperature recorded was 97°·1 on the 15th in 1881, and the absolute lowest 38°·7 on the 19th in 1863. The temperature rose to 90° or above on two days in succession in 1846, 1859, 1881, 1887, and 1900, and on three days in succession in 1868.

The average rainfall for the month of July is 2·45 inches; the greatest amount was 6·75 inches in 1888, and the least 0·10 inch in 1825. The heaviest fall in one day was 3·67 inches on the 26th in 1867. The average number of "rain days" (*i.e.*, on which 0·01 inch fell) is 12·6; the greatest number of days was twenty-six in 1888, and the least two in 1869. The average number of thunderstorms is 2·5.

The average amount of bright sunshine at the Kew Observatory, Richmond, is two hundred and four hours, or forty-one per cent. of the possible duration. The average barometric pressure in London is 29·964 inches; the highest mean was 30·240 inches in 1880, and the lowest mean 29·706 inches in 1816.

FREQUENCIES OF CLOUD-FORMS IN EGYPT.—Cloud observations have been made regularly five times a day at the Helwan Observatory, near Cairo, since its equipment in 1904. Mr. N. A. Comissopulos has tabulated these observations (over eighteen thousand) for the ten years 1904–13, and has given the results in the *Cairo Scientific Journal* for September, 1914. It appears that clear skies occur most frequently, being forty-nine per cent. of the total number of observations. Upper clouds, including cirrus, cirro-stratus, and cirro-cumulus, are more frequent than any other class, while intermediate clouds (alto-stratus and alto-cumulus) are practically absent. This would, on the whole, be expected from the dry character of Egyptian weather, but the absence of the intermediate clouds is striking. Clear skies have their minimum at 8 a.m., and maximum at 8 p.m.

ISOMERIC RAINFALL MAPS.—At the meeting of the Royal Meteorological Society on November 18th Dr. H. R. Mill and Mr. C. Salter submitted a paper on "Isomeric Rainfall Maps of the British Isles." The average monthly rainfall expressed as a percentage of the average annual

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fall of each of about three hundred stations for the thirty-five-year period, 1875–1909, formed the basis of a set of twelve monthly and four seasonal maps. Taking the whole country, the months from February to June inclusive are each respectively the driest in one place or another, whilst from July to January each month, except September and November, is the extreme month in any part of the country, and no month is wettest in one part and driest in another. The most striking features brought out by the maps are the occurrence of two types of seasonal march: one, chiefly characteristic of western or wet districts, having a winter maximum and a summer minimum, the other, chiefly confined to eastern or dry districts, having a winter minimum and a summer or autumn maximum. The equinoctial maps show the transitional stage between these two extremes, the spring months having everywhere a low rainfall and small range, with a central maximum inland and a peripheral minimum on the coast, and the autumn months a large rainfall with a central minimum and a peripheral maximum. The maps show that the relation of heavy rainfall with high-lying land is a relation of cause and effect; the relation of the winter maximum with the heavy rainfall is therefore an indication of a common cause. High land is only associated with heavy rain because it meets rain-bearing winds, and the true connecting circumstances are the position of high land and its relation to the prevailing winds. The occurrence of rain with easterly winds, affecting principally the east coast, makes it impossible to view the British Isles as having a rainfall régime solely produced by south-westerly winds. The far greater frequency of southerly and westerly winds than of easterly and northerly, and the fact that the latter occur mainly at certain seasons, go far to explain the features both of the average rainfall maps and of the isomeric maps.

MAN AND CLIMATE.—Sir Charles P. Lucas, the President of the Geographical Section of the British Association at the Australian meeting, took for his address, "Man as a Geographical Agent." In speaking of climate, he said "climates are hot or cold, wet or dry, healthy or unhealthy. Here our old friends, the trees, have much to say. Climates, beyond dispute, become at once hotter and colder when trees have been cut down and the face of the earth has been laid bare; they become drier or moister according as trees are destroyed or trees planted and hold the moisture; the cutting and planting of timber affects either one way or the other the health of a district. The tilling of the soil modifies the climate. This has been the case, according to general opinion, in the north-west of Canada. In winter time broken or ploughed land does not hold the snow and ice to the same extent as the unbroken surface of the prairie; on the other hand, it is more retentive at once of moisture and of the rays of the sun. The result is that the wheat zone has moved further north, and that the intervention of man has, at any rate for agricultural purposes, made the climate of the great Canadian north-west perceptibly more favourable than it was. In Lord Strathcona's view, there was some change even before the settlers came in—as soon as the rails and telegraph lines of the Canadian Pacific Railway were laid. He told me that in carrying the line across a desert belt it was found that, within measurable distance of the rail and telegraph line, there was a distinct increase of dew and moisture. Reference has already been made to the effect of cultivation in the Kalahari Desert in increasing the storage of moisture in the soil. But it is when we come to the division between healthy and unhealthy climates that the effect of science upon climate is most clearly seen. The great researches of Ross, Manson, and many other men of science, British and foreign alike, who have traced malaria and yellow fever back to the mosquito, and assured the prevention and gradual extirpation of tropical diseases, bid fair to revolutionise climatic control."

ROYAL OBSERVATORY, GREENWICH.—The Astronomer Royal, in his report to the Board of Visitors on June 5th, stated that the mean temperature for the twelve months ended April 30th, 1915, was 50°·2, or 0°·7 above the average. The rainfall for the same period was 24·73 inches, or 0·61 inch greater than the average. September, with 0·73 inch, was the driest month, and December, with 6·02 inches, the wettest; it was, in fact, the wettest December in the Greenwich series, and the three winter months, with 12·86 inches, the wettest winter in one hundred years.

The mean values of the magnetic elements for 1914 and three previous years are as follows:—

	Declination W.		Dip.
	° ′		° ′ ″
1911	15 33·0	...	66 52 6
1912	15 24·3	...	66 51 46
1913	15 15·2	...	66 50 27
1914	15 6·3	...	66 49 27

MICROSCOPY.

By F.R.M.S.

INSECTS' LANCETS.—In examining the mouth-organs of some of the blood-sucking insects by which we are occasionally attacked, the microscopist cannot fail to be impressed by their marvellous construction and perfect adaptation to the ends which they are intended to serve, the marvel being the greater when it is considered that these elaborate structures are developed during the comparatively short space of time passed in the pupa condition. The mandibles of the tiny midge, for instance, are seen to be two triangular blades, the inner margins of which, from the point to the obtuse angle, are armed with seventeen to twenty glittering teeth—about the eight thousandth of an inch apart—each of which is *separately inserted* into the edge, and appears to be composed of a harder material than the blade itself. In the case of the gadfly the mandibles are much longer, and are lancet-shaped: they are made of hard chitin, smooth and sharp on the outer edge, but very finely serrated on the inner. These teeth are slightly curved, and point backwards, varying in number and closeness in individuals and species from about fifteen thousand to the inch in the "golden eye" (*Chrysops coecutiens*) to over twenty thousand in *Tabanus luridus*. It is difficult to say if these are separately inserted; but since when placed in the dark field produced by two crossed nicol prisms a bright streak is seen to run from the point along the serrated edge of this organ, it is assumed that they are somewhat harder than the rest of the blade. When, however, we examine the maxillae of the same fly, we find these to be nearly straight, about the same length as the mandibles, but averaging not more than the two hundredth of an inch in width, slightly tapering towards the end, and rounded at the tip. The latter is closely covered with reflexed teeth, the point of each being formed of some crystalline substance set in a socket of softer material arising directly from the surface of the maxilla. These teeth are largest near the extremity of the organ, where they can easily be seen under a half-inch objective. About ten rows down they divide into two columns, each about seven teeth wide, extending half the length of the maxilla, and leaving the central portion bare. The teeth on the inner side lie near the edge, but the outer margin of each maxilla is fringed with delicate hairs. The possible use of these teeth, like those on the hypostome of a tick, is to give a firm hold in the sides of the incision whilst the blood is drawn up between the labium and the ligula.

In the more familiar flea the mandibles are long and narrow, with nearly parallel margins, averaging about the eightieth of an inch in length by the one thousand two hundred and fiftieth of an inch in breadth, both edges of which are set with sharp, rounded teeth, each of which is separately inserted like those of the midge. Immediately behind these is a second row of smaller teeth, the total number on each mandible thus being rather over three hundred. The irritation and inflammation caused by the

" bite " of these insects vary no doubt according to the state of health of the person bitten ; but it has been thought by some partly to arise from the action of a fluid which they inject at the time for the purpose of rupturing the red corpuscles which might otherwise choke the minute tubes through which the blood is drawn. This, however, is a question for the physiologist rather than for the microscopist to determine.

R. T. L.

FAMILIES OF THE POLYCHAETA RECOGNISABLE BY THEIR POSSESSING CHARACTERISTIC CHAETAE.—Chaetae are objects of great beauty and diversity, and should on that account attract many amateurs to the study of the Polychaeta.

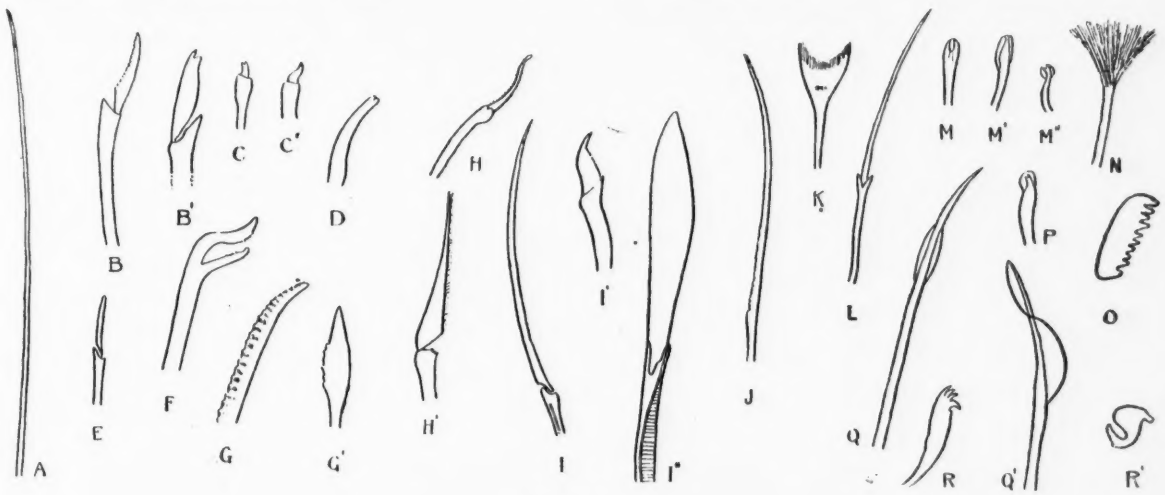

FIGURE 190.

Chaetae are of two main types :—

(1) *Simple*, i.e., unjointed, of which the *simple capillary* is the most common, occurring often together mixed up with other types, and is not therefore specially characteristic. Type A (see Figure 190).

(2) *Compound*, i.e., jointed.

Order Nereidiformia.—Only in this order do compound chaetae occur. *Crotchets* (hooked or hooded) do not occur (except in the Eunicidae). *Uncini* do *not* occur.

Syllideae.—The chaetae of this family present many variations, but those of the tribe Syllideae generally conform to the Types B, B′, while those of the tribe Autolyteae conform to the Types C, C′. Some, however, of the Syllideae also conform to C, C′. In this family simple chaetae also occur ; some of the Type D.

Hesionidae.—The chaetae of this family all conform to the Type E.

Amphinomidae (Euphrosynidae).—Only in this family occurs the *simple fork*, which is very characteristic and of large size, easily distinguishable under the low magnification. Type F.

Polynoidae.—Only in this family occurs the *simple spear* on which fifty different changes may be rung, Types G and G′ being extreme examples. Thus in *Gattyana* alone six different varieties are found. Only in the sub-family Sigalioninae do compound chaetae occur, and these conform somewhat to Types C, C′.

Phyllodocidae.—Compound chaetae of Types H, H′.

Nereidae.—Compound chaetae of Types I, I′ ; at sexual maturity (*Heteronereis* form) of Type I″.

Nephthydidae.—No compound chaetae ; broad simple chaetae with entire or serrated edge, often with markings. Type J.

Eunicidae.—Only in this family do *simple combs* occur ; and, though they only occur in the commoner members, they are not present in any other family, so that their presence is characteristic. Type K. They are extremely small, and should be carefully looked for with a high power near the gill, which is a modified dorsal cirrus. Only two or three are found in one parapodium. A great many other types of chaetae, both simple and compound, occur in this family.

Glyceridae.—Compound chaetae of Type L. Simple capillary chaetae also occur.

Order Spioniformia.—*Hooked Crochets* usually occur. *Uncini* occur in the Chaetopteridae.

Spionidae.—*Hooked Crochets* of Types M, M′.

Polydoridae.—*Hooked Crochets* of Type M″ ; simple capillary chaetae also occur.

Chaetopteridae.—Whilst no one could mistake *Chaetopterus*, it is interesting to note that only in this family does the *simple brush* occur in the anterior parapodia. Type N. Simple capillary chaetae also occur. *Uncini* of Type O occur in the posterior parapodia.

Order Capitelliformia.—Simple chaetae, and crotchets occur of Type P.

In the remaining orders simple chaetae occur of the Types Q, Q′, and *Uncini* of the types R, R′. Simple capillary chaetae are practically ubiquitous.

The figures are drawn from the following animals :—

A. *Glycera.*	J. *Nephthys.*
B. *Gattiola* (*Amblyosyllis*).	K. *Eunice.*
B′. *Trypanosyllis.*	L. *Glycera.*
C. *Autolytus.*	M. *Scolecolepis.*
C′. *Myrianida.*	M′. *Spio.*
D. *Ehlersia.*	M″. *Polydora.*
E. *Castalia.*	N. *Chaetopterus.*
F. *Euphrosyne.*	O. *Chaetopterus.*
G. *Gattyana* (*Nychia*).	P. *Capitella.*
G′. *Polynoë.*	Q. *Arenicola.*
H. *Eulalia.*	Q′. *Dasychone.*
H′. *Phyllodoce.*	R. *Arenicola.**
I, I′, I″. *Nereis.*	R′. *Dasychone.*

W. HAROLD LEIGH-SHARPE, B.Sc., A.C.P.

* From a post-larval specimen ; in this genus, as the animal grows older, *uncini* are developed with fewer teeth, but not in other genera.

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THE QUEKETT MICROSCOPICAL CLUB.—At the five hundred and eighth Ordinary Meeting of the Quekett Microscopical Club further notes on the cultivation of Plasmodia of *Badhamia utricularis* were given by Mr. A. E. Hilton. He stated that it is possible to cultivate the spores, but not always easy. With regard to the question whether *Badhamia* forms sporangia when artificially fed, he was able to say that it would, but with certain reservations.

The Secretary then read a paper on *Hydrodictyon reticulum* or *utriculatum*, of which, in September last, he found an immense quantity in the lake at Kew Gardens.

Mr. Perks read some notes by Mr. E. M. Nelson on various insect structures. Among them were the mandibles of a gadfly (*Tabanus bovinus*), which show the most wonderful saw in the world, having ten thousand to sixteen thousand teeth per inch on one edge, while the other is the keenest blade in existence.

Mr. Nelson points this out as a test object, as podura test scales are now not to be had. One may pay £1 for a slide and not find a test scale upon it.

PHOTO-MICROGRAPHY.—When mentioning the interesting booklet which Messrs. Kodak, Limited, have recently reissued, we promised to illustrate in the present number of "KNOWLEDGE" the results obtained by following the directions given. Everyone is agreed that photography has its limitations, and that sometimes drawings are better than photo-micrographs for showing details of structure; but it will be obvious, on looking at Figure 198, that it is possible to get a very considerable amount of detail, if the right plates and filters are used, even in the case of plant tissues, which are among the objects to illustrate which drawings are usually considered to be necessary. Again, many pictures of insects taken through the microscope are little better than silhouettes. It is interesting in this connection to look at the figures on page 213. Figure 191 is from a photo-micrograph on an ordinary plate, and is what one would expect to obtain from a horn-coloured original. The orthochromatic plate gives a little better result, and this is improved upon when the Wratten filters B (green) and G (yellow) are used, as the orthochromatic plate is sensitive to yellow and green light. When the M plate, which is a panchromatic plate of very fine grain, and capable of giving great contrast, is used with filters A (scarlet) and D (purple), we get a really detailed photo-micrograph, which is at the same time accurate and pleasing to the eye. The second series of pictures, on page 214, illustrates what can be done with a specimen that is stained red and green. With the M plate and the B (green) filter (see Figure 197) the ground tissue in the centre, as in the case of the ordinary plate, is over-emphasised; but, as already mentioned in Figure 198, when the M plate and the F filter (pure red) are brought into play, the result is extremely good. We strongly recommend those of our readers who are interested in photo-micrography to obtain a copy of the booklet, which is sold for threepence, and also to take advantage of all the experimental work which the Wratten division of Messrs. Kodak, Limited, is able to put at their disposal.

W. M. W.

PHOTOGRAPHY.

By EDGAR SENIOR.

PRINTS UPON MATT-SURFACE COLLODIO-CHLORIDE PAPER.—While there are many photographers who greatly admire prints made both in carbon and platinum, they are deterred from practising either of these processes—in the one case from the supposed difficulties attending it, and in the other from the cost of the material itself. For such the matt-surface collodio-chloride paper, that is readily obtainable, should fill a want, since it can be made to imitate prints in carbon or platinum. It is true that it is only an imitation, but it is perhaps a better one than can be got with most other papers that are sometimes employed to give like effects. A great range of tone can be obtained by the use of one kind of paper and the usual manipulation. Then, again, it has often been stated that prints made upon collodio-chloride paper are permanent; but this appears greatly to depend upon the method of treatment employed, and our own experience is that when the various operations are properly conducted the prints are more permanent than those made upon albuminised or gelatino-chloride papers generally. One great drawback to the process is the curling of the prints during the various manipulations, the liability of the surface to crack, and the care required to prevent yellow spots making their appearance. The paper should not be handled more than is necessary, otherwise red stains may occur where the surface has been in contact with the fingers. The paper when cut should be kept in a box with a close-fitting lid and under slight pressure. Untoned prints should be stored in a similar way, and may then be kept for some time between printing and toning, although it is better that the latter operation should not be delayed for more than two or three days, as the collodion film is liable to become horny. The class of negative that is best suited for this kind of paper is one that possesses good contrasts, thin or flat ones only giving poor prints. Then the printing must be carried much further than is required with most other printing-out papers, the operation being continued until the highest lights are tinted and the shadows bronzed. A little practice will soon give the necessary experience in this matter. The toning of prints made upon collodio-chloride paper may be accomplished by any of the usual toning solutions recommended, the prints being toned entirely in a gold toning bath, or transferred finally to one containing a salt of platinum to finish. The former method is quicker and cheaper, but the colder tones are not so good as when a second bath of potassium chloro-platinite is used as well. Before proceeding to tone the prints they must be washed in five or six changes of water during about fifteen minutes, in order to free them from soluble silver salts, or until there is no appearance of milkiness imparted to the water. There should only be sufficient water placed in the dish at first just to cover the prints, each one as it is introduced being placed face down and pressed against the bottom of the dish, to prevent the paper from curling. For toning the prints a borax bath is generally recommended, as it works quickly and tones regularly with freedom from double tones. Although the borax bath alone has been found suitable for most papers, it has not been so in every case. We therefore give two formulas, either of which may be used as occasion requires:—

Borax (powdered)	32 grains
Gold chloride	1 grain
Water	10 ounces

or

Soda acetate	75 grains
Borax (powdered)	75 grains
Gold chloride	1 grain
Water	17·5 ounces

Either of these baths should be prepared a short time before required for use, and after use thrown away. Great care must be exercised when toning in the gold bath, as it decides the final colour that the prints will assume. Practice alone will enable the worker to secure the exact colour; but as a guide we may say that, where a brownish-black is required, a short immersion only in the gold bath must be given, while for a bluish-black the shadows must assume a violet hue, and when pure blacks are required the prints must be toned until they are of a chocolate colour. It will thus be evident that by allowing a longer or shorter time in the gold bath, a fine range of black tones is readily obtained. After toning, the prints should be well washed in several changes of water for about ten minutes, when they will be ready for platinum toning. A stock solution of potassium chloro-platinite may be made up as follows:—

Potassium chloro-platinite ...	15 grains
Phosphoric acid, sp. gr. 1·12 ...	1·5 drams
Water (distilled)	2·5 ounces

FIGURE 191. Ordinary Plate.

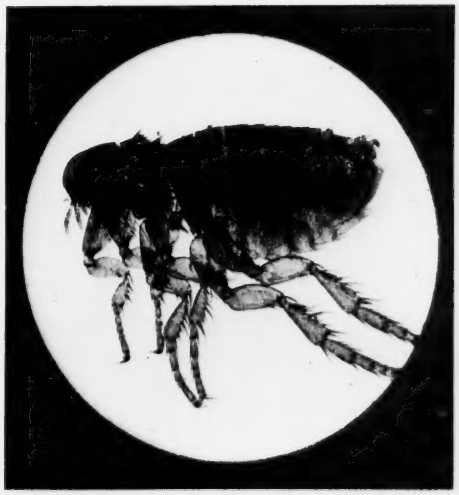

FIGURE 192. Orthochromatic Plate with no filter.

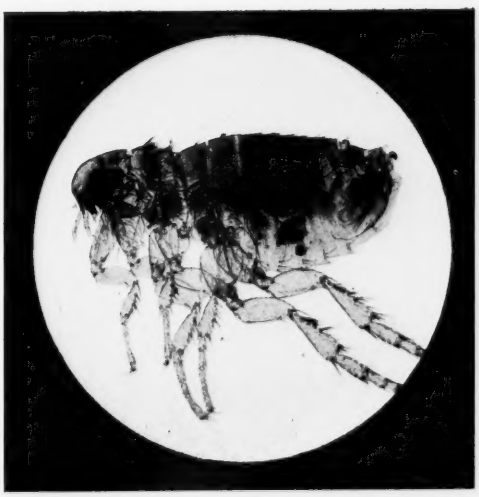

FIGURE 193. Orthochromatic Plate with B and G filters.

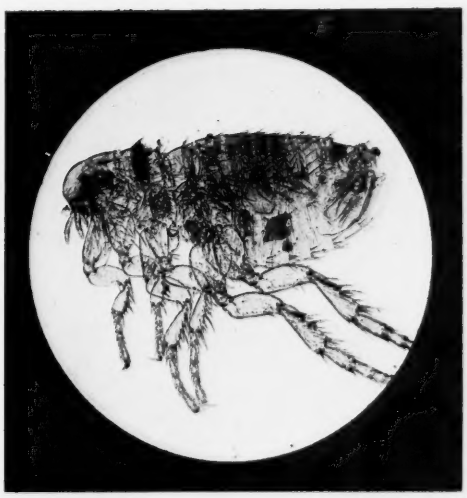

FIGURE 194. "M" Plate with A and D filters.

DOG FLEA.

The Specimen is unstained.

(By kind permission of Messrs. Kodak, Limited.)

XUM

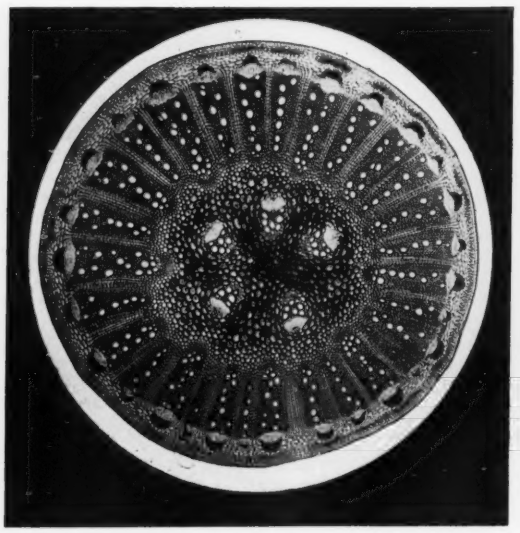

FIGURE 195. Ordinary Plate.

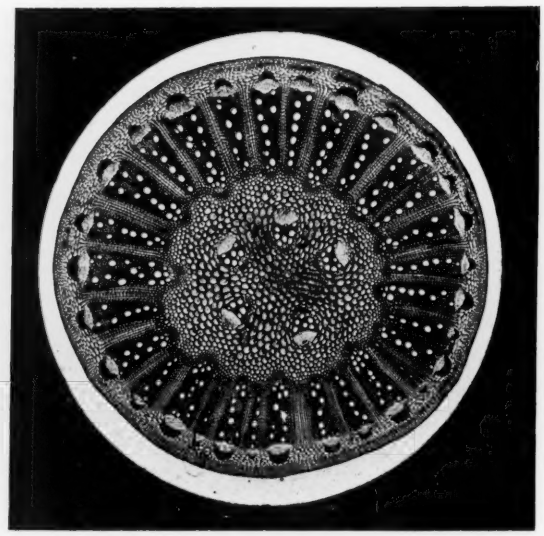

FIGURE 196. Pan Plate and K3 Filter.

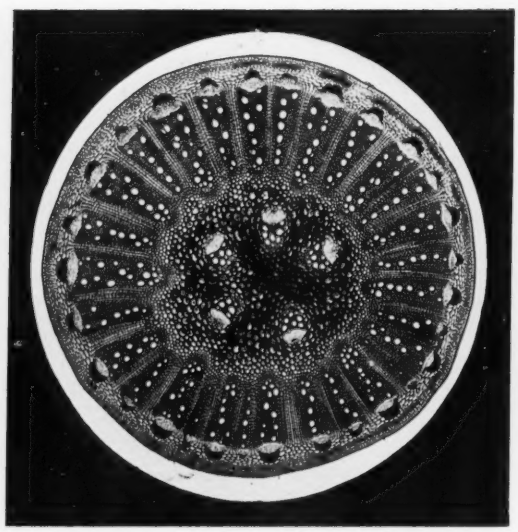

FIGURE 197. "M" Plate and B Filter.

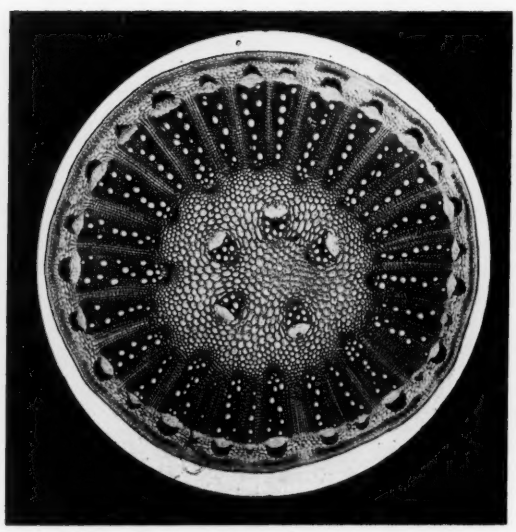

FIGURE 198. "M" Plate and F Filter.

PEPPER STEM: TRANSVERSE SECTION.

The Specimen is stained red and green.

(By kind permission of Messrs. Kodak, Limited.)

The toning bath is prepared by taking thirty minims of above for every ounce of water. The prints are placed in this solution contained in a dish, and kept moving until they have reached the desired tone, or until when viewed by transmitted light all the warmth has gone from the shadows. This operation is generally complete in about three minutes. When the prints are toned, they must be very thoroughly washed, in order to remove every trace of phosphoric acid, since any trace left in the paper leads to rapid fading. The washing should be continued for at least fifteen minutes, during which time some six or eight changes of water may be given. It is also a good plan finally to place the prints in water, containing a little soda carbonate, for a few minutes, and rinse again in one or two changes of water. The prints should then be fixed in a bath of the following strength :—

"Hypo"	...	...	...	...	3 ounces
Water	...	...	...	...	20 „

The time of immersion in the above bath should not be less than fifteen minutes, to ensure thorough fixation, after which the prints should be washed in several changes of water, in order to remove the greater part of the fixing agent, and finally left for two hours in running water. A strong force of water should not be allowed directly to impinge on the surface of the prints, as there is a risk of the film becoming damaged.

PHYSICS.

By J. H. VINCENT, M.A., D.Sc., A.R.C.Sc.

SPECIFIC HEAT OF COPPER.—In the course of some determinations of the mechanical equivalent of heat, Harper (*Bureau of Standards Bulletin*, 11, 1915) found it necessary to find the specific heat of chemically pure copper between 0° and 50° C. This he did by a novel method, in which a coil of wire serves the fourfold function of being the test-piece, the calorimeter itself, the heater, and the thermometer. The wire is wound non-inductively, and suspended in a vacuum. It is heated with a measured quantity of electrical energy, the consequent rise of temperature being found by its change in resistance. The result is that $s = \cdot3834 + \cdot00020(t - 25)$, in which the specific heat at any centigrade temperature is given in international joules per gramme degree.

THE CHANGE OF THERMAL CONDUCTIVITY WITH FUSION.—At first sight it seems that the problem of finding the change of conductivity for heat produced in a metal by fusion would prove exceedingly troublesome. Porter and Simeon, in a paper recently communicated to the Physical Society of London, have devised a simple and elegant method by which this ratio has been obtained in the case of mercury and of sodium. The metal is contained in a vertical glass tube, maintained at such temperatures that the liquid occupied one-half of the tube and the solid the other. A series of thermo-junctions inserted in narrow depressions in the side of the glass tube served to determine the temperatures, and the ratio of the thermal conductivity for solid and liquid was estimated from the slope of tangents drawn to the temperature curve on each side of the melting-point. The values of these ratios are of the same order as the ratio of the corresponding values of the electrical conductivities. The mean value for mercury is 3·91, and for sodium 1·31.

THE RELATIVE DIMENSIONS OF MOLECULES.—By the application of a correction due to Sutherland to the Maxwell equations for the viscosity of a gas, it has been shown by Rankine (*Phil. Mag.*, April, 1915) that some interesting relationships between the sizes of the molecules are brought to light. For this purpose it does not suffice to find the viscosity of a gas at a given temperature, but the variation with temperature must also be determined. Rankine has recently made such measurements for a considerable number of gases, the gases selected being the three members of the group of inert gases, argon, krypton, and zenon, and the three corresponding members of the halogen group, chlorine, bromine, and iodine. The molecular radii of these gases are given by Rankine. In each series they ascend with the atomic weight. The molecular radius of chlorine is $1{\cdot}6 \times 10^{-8}$ centimetres. There is a constant ratio between the molecular radii of corresponding members of the series, so that the radius of the molecule of a halogen gas is 1·24 times that of the corresponding inert gas.

A FURTHER EXTENSION OF THE SPECTRUM.—Lyman has previously announced that he had extended the ultra-violet limit of the spectrum to the neighbourhood of wave-length 900 tenth-metres. In a letter to *Nature* (May 27th, 1915) he now records his success in carrying the observations to wave-length 600. This result is chiefly due to the use of helium of considerable purity in his spectroscope and discharge tube. The apparatus is an air-tight grating vacuum spectroscope. The spectrum, which is obtained with a disruptive discharge in helium, contains between the wave-lengths 1250 and 600 upwards of fifteen lines, some of them of considerable strength.

THE BARNARD MEDAL.—We learn from *Science* that the Barnard gold medal, awarded every fifth year by Columbia University, on the recommendation of the National Academy of Sciences, "to that person who, within the five years next preceding, has made such discovery in physical or astronomical science, or such novel application of science to purposes beneficial to the human race, as may be deemed by the National Academy of Sciences most worthy of the honor," will be given this year to William H. Bragg, D.Sc., F.R.S., Cavendish Professor of Physics in the University of Leeds, and to his son, W. L. Bragg, of the University of Cambridge, for their researches in molecular physics, and in the particular field of radio-activity. The previous awards of the Barnard medal have been as follows :—

1895. Lord Rayleigh and Professor William Ramsay.
1900. Professor Wilhelm Conrad von Röntgen.
1905. Professor Henri Becquerel.
1910. Professor Ernest Rutherford.

RADIO-ACTIVITY.

By ALEXANDER FLECK, B.Sc.

RADIO-ACTIVITY AND GEOLOGY.—A number of papers has recently appeared dealing with the interrelation of these two subjects, but no very satisfactory conclusions seem to have been reached. On the whole, this is scarcely to be wondered at considering that radio-active information which would be of use to geologists is very imperfectly known. This is well illustrated in the case of methods of arriving at the total quantity of radium in the earth. Estimates of this can be made, but they are based on so many assumptions that they are of little value ; and so any calculations made from these estimates to deduce the amount of heat generated inside the earth can at best give only a possible value. The general conclusion, then, is this, that radio-active evidence may support, but is not vital to, any theories based on geological evidence.

PHOTOGRAPHIC EFFECT OF RADIO-ACTIVE RAYS.—The fact that uranium salts can act on photographic plates to give an effect similar to that obtained by the action of light was one of the early experiments which led to the conception of radio-activity. With the exception of certain valuable experiments, this property has been little used for accurate work in the latter stages of the subject, owing to the difficulty of measuring the effect produced, and as a consequence our knowledge of what exactly happens when the α, β, or γ rays are absorbed in a photographic plate is very incomplete. In view of this a paper by Professor Sahni, of Lahore, in the June number of *The Philosophical Magazine* is of considerable interest.

XUM

A quantity of radio-active material on the point of a fine needle was placed beside a specially selected type of photographic plate, which was then developed in the usual way. A microphotograph of this developed plate was then taken, and a number of examples of the result is published with the paper. These show that it is quite easy to distinguish between α and β, or between α and γ, but so far it is not possible to discriminate between the effects produced by β and γ rays.

AN UNKNOWN RADIATION.—In a recent number of *The Journal of the American Chemical Society* (Volume XXXVII, page 549) C. A. Doremus describes some curious effects. In the course of some experiments on the formation of calcium carbide by the interaction of lampblack and a calcium-zinc alloy, this worker had occasion to sit with a furnace between his knees. The furnace, heated to a dull red heat, contained the alloy, and into it he was feeding lampblack. No effects were immediately felt, but shortly afterwards the area of skin nearest the furnace became blistered, and remained in an inflamed condition for four months. The effects, in fact, were in every way similar to "burns" produced by x rays. The experiment was repeated, this time a photographic plate behind a lead screen with holes cut in it being used in place of human epidermis, and again the presence of a radiation similar to x rays was detected. If the experiment was carried out with other forms of carbon, such as coke, charcoal, or gas carbon, in place of lampblack, no radiation was detected.

So far as one can judge from reading the paper, the effects observed seem to be real, and it is to be regretted that the author did not continue his experiments so that either the phenomenon could be explained or the existence of a new type of radiation definitely established.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

RECORD TUSKS OF WALRUS.—Sir Edmund G. Loder exhibited to the Zoölogical Society of London the skull of a walrus from Kamschatka with record tusks. They weighed twenty-one and a half pounds, and measured thirty-six and a half inches in length, twenty-nine and a half inches from outside the gum, and nine and five-eighth inches in girth.

MONACO MUSEUM.—We have received an attractive illustrated guide to the magnificent oceanographical museum at Monaco, of which Dr. J. Richard is director. Among the forms well illustrated we note the soft sea-urchin (*Sperosoma grimaldii*), the extraordinarily spinose stone-crab (*Neolithodes grimaldii*), some indescribable abyssal fishes, such as *Gastrostomus bairdi* with its maximum of gape, and the fins of the scaly cuttlefish (*Lepidoteuthis grimaldii*). The museum is particularly rich in its display of all sorts of appliances connected with oceanographical research.

IODINE IN MARINE ANIMALS.—Investigations by Dr. A. T. Cameron at Vancouver Island show that most of the marine animals, except free-floating forms, contain iodine, just as most seaweeds do. In fishes it is practically confined to the thyroid gland. It was found in marked quantity in the tube of a Serpulid worm (*Diopatra*), in the cellulose test of the Tunicate *Pyura*, and in the cuticle of the horse-clam (*Schizothoerus*). In the Serpulid and Bivalve, as also in Sponges and Gorgonid corals, the iodine occurs along with some sclero-protein, such as spongin and gorgonin.

SPECIES OF NO-BODY CRABS.—In describing a new genus (*Mayerella*) of Caprellid from the Bay of Fundy, Dr. A. G. Huntsman remarks: "The various genera in this group result from a ringing of the changes on a comparatively small number of characters. Nearly all possible combinations of these characters are to be found. This is analogous with the way in which among chemical compounds a large proportion of the possible combinations of certain radicles or elements may be obtained. I believe that the analogy is due to the fact that in each case the basis is a chemical one."

FEEDING OF GLOW-WORM LARVAE.—Miss Kathleen Haddon has made an interesting study of the mouth-parts and mode of feeding in the larvae of the glow-worm (*Lampyris noctiluca*). The larva eats snails and leaves no residue; yet no solid food can enter its mouth. It has strong mandibles, perforated by a canal through which a dark-coloured fluid—probably from the mid-gut—exudes. But there does not seem to be any anaesthetising of its victim, as Fabre thought. The mandibles work continuously, and the juices of the snail are sucked into the very narrow gullet by the suction-pump action of the pharynx. The juices are strained through the numerous hairs surrounding the mouth, and adherent particles are cleaned off after a meal.

STRANGE HABITAT FOR A WORM.—A small Oligochaete worm of the family Enchytraeidae, widely represented in freshwater, was found by Mr. H. A. Baylis in considerable numbers in the gill-chambers of land-crabs (*Gecarcinus lagostoma*) from South Trinidad. It has been named *Enchytraeus carcinophilus*, and it is rather interesting that another species, *E. parasiticus*, has more recently been found on and among the gills of *Gecarcinus quadratus* from Clarion Island in the Pacific. As these worms are without jaws, it is difficult to know what they eat unless it be mucus formed in the gill-chamber.

THE REDUCTION OF THE FORTUITOUS.—Many thinkers have been impressed, and some have been depressed, by the fortuitousness of organic evolution. Indefinite variations, kaleidoscopic changes, sports, and freaks—that's the raw material of progress! Callous physical environment, vicissitudes of "weather" in the widest sense, unmeaning swaying of competition, now to one side and again to another—that's the sifting that makes a cosmos! But the outlook is changing as facts accumulate. Variations are often definite, orthogenetic, and significant; so often that some of us think they may be regarded as germinal experiments in self-expression; and, as regards selection, the very important fact has not been adequately appreciated that the sifting that goes on is not blind or haphazard, but, because of the web of life, in definite relation to what has been already established. The character of the building that has been erected determines the character of the additions made to it.

SMELL IN INSECTS.—There is no doubt that many insects have a keen sense of smell, but there has been much discussion as to the seat of the sense. The most generally accepted view is that the sense is located in the antennae, which bear several different kinds of sensory structures. This view is strengthened by the fact that insects, bereft of their antennae, do not show the usual reäctions to odour. They may respond slowly or not at all. Dr. N. E. McIndoo, of the Bureau of Entomology in Washington, points out, however, that Hymenoptera and other insects are very seriously disorganised when their antennae are removed, and it may be that the changes in the reäctions to odours are due to general abnormality of behaviour, and not to the removal of the olfactory structures. This is an important criticism, which should be borne in mind in analogous cases. Dr. McIndoo also points out that Spiders have a good sense of smell, though they have no antennae. He finds the seat of smell in Hymenoptera in numerous pores, with exposed nerve endings, on the bases of the wings, on the legs, on the sting of Worker and Queen Bee, and on the mouth parts. The Drone Bee has two thousand six hundred and eight pores; a small Wasp has six hundred and eighty-eight of them. Attention was first directed to these structures by Hicks in 1857, and they have since been studied by Janet, McIndoo, and others. If they are varnished with vaseline or the like the reäction times to scent stimuli are greatly increased. They correspond to Bertkau's lyriform or slit-like organs in Spiders.

XUM

THE FACE OF THE SKY FOR AUGUST.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 34.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Uranus. R.A.	Uranus. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Aug. 4	8 53·9	N.17·5	3 40·6	N.24·9	8 10·7	N.21·1	8 10·7	N.20·8	5 17·2	N.23·1	23 55·3	S. 2·1	6 45·7	N.22·4	21 5·9	S.17·4
,, 9	9 13·1	16·1	8 5·6	N.22·0	8 53·4	19·1	8 36·4	19·5	5 31·7	23·3	23 54·2	2·2	6 48·3	22·4	21 5·1	17·4
,, 14	9 32·0	14·6	12 8·5	S. 5·1	9 34·7	16·3	9 1·6	18·0	5 46·1	23·5	23 52·9	2·4	6 50·7	22·3	21 4·3	17·5
,, 19	9 50·7	13·1	16 48·5	S. 27·2	10 13·1	12·8	9 26·4	16·3	6 0·3	23·6	23 51·3	2·6	6 53·0	22·3	21 3·6	17·5
,, 24	10 9·2	11·4	21 48·4	S. 12·5	10 48·1	9·1	9 50·8	14·4	6 14·4	23·7	23 49·5	2·8	6 55·3	22·2	21 2·8	17·6
,, 29	10 27·6	N. 9·7	1 46·0	N.16·3	11 20·1	N. 5·3	10 14·8	N.12·3	6 28·4	N.23·6	23 47·5	S. 3·0	6 57·4	N.22·2	21 2·1	S.17·6

TABLE 35.

Date.	Greenwich Noon. Sun. P	Sun. B	Sun. L	Moon. P	Greenwich Midnight. Mars. B	Mars. P	Mars. L	Mars. T	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
	°	°	°	°	°	°	°	h. m.	°	°	°	°	h. m.	h. m.
Aug. 4 ..	+ 11·9	+6·0	132·4	−11·4	Aug. 6 .. −28·9	−1·5	118·8	3 51 *e*	Aug. 7 ..	−25·5	+2·2	122·8	233·1	0 57 *m*	5 34 *e*
,, 9 ..	13·8	6·4	66·3	+12·6	,, 12 .. 27·3	+0·1	60·6	7 51 *e*	,, 14 ..	25·5	2·2	149·0	205·9	7 55 *e*	6 19 *e*
,, 14 ..	15·6	6·6	0·2	+22·4	,, 18 .. 25·5	1·7	2·4	11 50 *e*	,, 21 ..	25·5	2·3	175·2	178·7	9 22 *m*	7 4 *e*
,, 19 ..	17·3	6·8	294·1	+ 4·8	,, 24 .. 23·6	3·3	304·3	3 9 *m*	,, 28 ..	−25·5	+2·3	201·5	151·6	8 39 *m*	7 49 *e*
,, 24 ..	18·8	7·0	228·0	−19·4	,, 30 .. −21·7	+4·8	246·2	7 8 *m*							
,, 29 ..	+ 20·3	+7·2	162·0	−19·5											

P is the position angle of the North end of the body's axis measured eastward from the North point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. T is the time of transit of the zero meridian across the centre of the disc. In the case of Jupiter System I refers to the rapidly rotating equatorial zone, System II to the temperate zones, which rotate more slowly. To find intermediate passages of the zero meridian of either system across the centre of the disc, apply to T_1 T_2 multiples of $9^h\ 50^m{\cdot}4$, $9^h\ 55^m{\cdot}6$ respectively. In the case of Mars apply multiples of $24^h\ 40^m$.

The data for the Moon and Planets in the Second Table are given for Greenwich Midnight, *i.e.*, the Midnight at the end of the given day.

The letters *m*, *e* stand for morning, evening. The day is taken as beginning at midnight.

THE SUN continues to move Southward. Its semi-diameter increases from 15′ 47″ to 15′ 52″. Sunrise changes from $4^h\ 23^m$ to $5^h\ 11^m$; sunset from $7^h\ 49^m$ to $6^h\ 49^m$. The Sun's surface is likely to repay careful scrutiny, owing to the recrudescence of activity.

ANNULAR ECLIPSE OF SUN, AUGUST 10–11.—Central eclipse begins August $10^d\ 8^h\ 59^m$ *e* Greenwich Time, in Longitude 129° 36′ East, Latitude 23° 0′ N. (some 600 miles East of Formosa). Central eclipse at Local Noon, August $10^d\ 10^h\ 52^m$ *e* Greenwich Time, in Longitude 161° 40′ West, Latitude 16° 30′ North (some 600 miles S.W. of Sandwich Islands). Central eclipse ends August $11^d\ 0^h\ 46^m$ *m* Greenwich Time, in Longitude 106° 36′ W., Latitude 22° 0′ S. The track of annularity lies entirely in the Pacific Ocean. Partial eclipse is visible in New Guinea (part), Japan, Korea, E. Siberia, and most of the islands of the North Pacific.

MERCURY is a morning star till the 14th, when it passes

TABLE 36. Occultations of Stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Time.	Disappearance. Angle from N. to E.	Reäppearance. Time.	Reäppearance. Angle from N. to E.
1915.			h. m.	°	h. m.	°
Aug. 7 ...	BD+26°·1082	7·0	—	—	3 30 *m*	262
,, 17 ...	WZC 954	7·3	6 49 *e*	143	—	—
,, 17 ...	WZC 955	6·8	8 3 *e*	55	—	—
,, 18 ...	Lacaille 6719	6·9	7 44 *e*	25	—	—
,, 18 ...	Stone 8802	7·0	8 14 *e*	43	—	—
,, 20 ...	BAC 6191	6·3	6 18 *e*	138	7 4 *e*	215
,, 25 ...	BAC 8017...	6·2	7 37 *e*	55	8 40 *e*	246
,, 26 ...	25 Piscium	6·2	10 6 *e*	56	11 15 *e*	235
,, 29 ...	101 Piscium	6·2	4 25 *m*	96	5 29 *m*	209
,, 30 ...	ε Arietis (double)	4·6	8 28 *e*	131	8 53 *e*	188
,, 30 ...	WZC 176	6·7	—	—	9 7 *e*	289

From New to Full disappearances occur at the Dark Limb, from Full to New reäppearances.

XUM

Superior Conjunction and becomes an evening star. Semi-diameter nearly constant during month 2½″. Illumination nearly Full.

VENUS is a morning star. Illumination almost Full. Semi-diameter nearly 5″. Venus is 8′ South of Mercury on 4th at noon.

THE MOON.—Last quarter $2^d\ 9^h\ 27^m\ e$. New $10^d\ 10^h\ 52^m\ e$. First quarter $18^d\ 2^h\ 17^m\ m$. Full $24^d\ 9^h\ 40^m\ e$. Apogee $5^d\ 3^h\ m$. Perigee $20^d\ 2^h\ e$, semi-diameter 14′ 47″, 16′ 15″ respectively. Maximum librations 3^d 7° S., 12^d 5° E., 17^d 7° N., 26^d 5° W., 30^d 7° S. The letters indicate the region of the Moon's limb brought into view by libration. E., W. are with reference to our sky, not as they would appear to an observer on the Moon (see Table 36). At the Full Moon on 24th the Moon enters the Earth's penumbra, and a smokiness will be visible on the Southern portion of the disc. The phenomenon is visible in Europe.

MARS is still badly placed, but may be observed as a morning star. Rises about midnight. Semi-diameter 2″·6. Width of unilluminated lune ½″.

JUPITER is a morning star, in Pisces; Equatorial diameter 49″, Polar 46″. Width of unilluminated lune ⅛″. Rises at $9^h\cdot5\ e$ on 1st, at $7^h\cdot9\ e$ on 31st.

Configurations of satellites at $1^h\ m$.

JUPITER'S SATELLITES.

Day.	West.		East.		Day.	West.		East.	
Aug. 1	432	○		1●	Aug. 17	4	○	32	1●
,, 2	42	⊙		3●	,, 18	41	⊙	3	
,, 3	4	○	123		,, 19	42	○	13	
,, 4	412	○	3		,, 20	41	⊙	2	
,, 5	42	○	13		,, 21	43	○	12	
,, 6	413	○	2		,, 22	4321	○		
,, 7	34	○	12		,, 23	432	○	1	
,, 8	321	○	4		,, 24	1	○	432	
,, 9	32	⊙	4		,, 25		⊙	243	
,, 10		○	1324		,, 26	2	○	134	
,, 11	12	○	34		,, 27	1	○	¾4	
,, 12	2	○	134		,, 28	3	○	124	
,, 13	13	○	24		,, 29	321	○	4	
,, 14	3	○	124		,, 30	32	○	14	
,, 15	321	○	4		,, 31	1	○	324	
,, 16	342	○	1						

The following satellite phenomena are visible at Greenwich:—$1^d\ 0^h\ 56^m\ 9^s\ m$, I. Ec. D., $4^h\ 15^m\ m$, I. Oc. R., $10^h\ 4^m\ 16^s\ e$, II. Ec. D., $10^h\ 8^m\ e$, I. Sh. I., $10^h\ 17^m\ 59^s\ e$, III. Ec. D., $11^h\ 12^m\ e$, I. Tr. I.; $2^d\ 0^h\ 26^m\ m$, I. Sh. E., $1^h\ 19^m\ 32^s\ m$, III. Ec. R., $1^h\ 28^m\ m$, I. Tr. E., $2^h\ 40^m\ m$, III. Oc. D., $2^h\ 55^m\ m$, II. Oc. R., $10^h\ 42^m\ e$, I. Oc. R.; $3^d\ 9^h\ 36^m\ e$, II. Tr. E.; $7^d\ 3^h\ 3^m\ m$, IV. Oc. D.; $8^d\ 2^h\ 50^m\ 39^s\ m$, I. Ec. D.; $9^d\ 0^h\ 2^m\ m$, I. Sh. I., $0^h\ 38^m\ 48^s\ m$, II. Ec. D., $0^h\ 58^m\ m$, I. Tr. I., $2^h\ 19^m\ 16^s\ m$, III. Ec. D., $2^h\ 20^m\ m$, I. Sh. E., $3^h\ 15^m\ m$, I. Tr. E., $9^h\ 19^m\ 12^s\ e$, I. Ec. D.; $10^d\ 0^h\ 29^m\ m$, I. Oc. R., $9^h\ 10^m\ e$, II. Tr. I., $9^h\ 41^m\ e$, I. Tr. E., $10^h\ 10^m\ e$, II. Sh. E., $11^h\ 58^m\ e$, II. Tr. E.; $12^d\ 10^h\ 37^m\ e$, III. Tr. E.; $15^d\ 3^h\ 40^m\ m$, IV. Sh. I.; $16^d\ 1^h\ 56^m\ m$, I. Sh. I., $2^h\ 44^m\ m$, I. Tr. I., $3^h\ 13^m\ 27^s\ m$, II. Ec. D., $4^h\ 14^m\ m$, I. Sh. E., $11^h\ 13^m\ 48^s\ e$, I. Ec. D.; $17^d\ 2^h\ 15^m\ m$, I. Oc. R., $9^h\ 10^m\ e$, I. Tr. I., $9^h\ 56^m\ e$, II. Sh. I., $10^h\ 42^m\ e$, I. Sh. E., $11^h\ 26^m\ e$, I. Tr. E., $11^h\ 31^m\ e$, II. Tr. I.; $18^d\ 0^h\ 48^m\ m$, II. Sh. E., $2^h\ 18^m\ m$, II. Tr. E., $8^h\ 41^m\ e$, I. Oc. R.; $19^d\ 8^h\ 42^m\ e$, II. Oc. R., $11^h\ 14^m\ e$, III. Tr. I., $11^h\ 20^m\ e$, III. Sh. E.; $20^d\ 2^h\ 1^m\ m$, III. Tr. E.; $23^d\ 3^h\ 50^m\ m$, I. Sh. I., $4^h\ 29^m\ m$, I. Tr. I.; $24^d\ 1^h\ 8^m\ 30^s\ m$, I. Ec. D., $4^h\ 0^m\ m$, I. Oc. R., $10^h\ 18^m\ e$, I. Sh. I., $10^h\ 55^m\ e$, I. Tr. I.; $25^d\ 0^h\ 34^m\ m$, II. Sh. I., $0^h\ 36^m\ m$, I. Sh. E., $1^h\ 11^m\ m$, I. Tr. E., $1^h\ 49^m\ m$, II. Tr. I., $3^h\ 26^m\ m$, II. Sh. E., $4^h\ 36^m\ m$, II. Tr. E., $10^h\ 26^m\ e$, I. Oc. R.; $26^d\ 10^h\ 57^m\ e$, II. Oc. R.; $27^d\ 0^h\ 12^m\ m$, III. Sh. I., $2^h\ 36^m\ m$, III. Tr. I., $3^h\ 20^m\ m$, III. Sh. E.; $31^d\ 3^h\ 3^m\ 18^s\ m$, I. Ec. D., $9^h\ 59^m\ e$, IV. Sh. I.

Notice that Satellites I and II may be seen simultaneously in transit on the 10th. It will be interesting to compare the satellites and their shadows on this occasion.

SATURN may be seen as a morning star, rising about $1^h\ m$. Polar semi-diameter 8″, Angle P − 6°·9, Major axis of ring 38½″, Minor 16″.

URANUS is in opposition on 7th in Capricornus.

NEPTUNE is invisible, having been in conjunction with Sun on July 24th.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
	°	°	
May 30 to Aug.	333	+ 28	Swift, streaks.
June—Aug. ...	310	+ 61	Swift, streaks.
,, —Sept. ...	335	+ 57	Swift.
,, —Aug. ...	303	+ 24	Swift.
July—Aug. ...	308	− 12	Slow, long.
July 25-Sept. 15	48	+ 43	Swift, streaks.
,, —Sept. ...	335	+ 73	Swift, short.
,, —Aug. ...	280	+ 57	Slow, short.
,, —Oct. ..	355	+ 72	Swift, short.
Aug. 10-13 ..	45	+ 57	Perseids. Swift, streaks.
,, —Sept. ...	353	− 11	Rather slow.
,, 15 ...	290	+ 53	Swift, bright.
,, 15-25 ...	291	+ 60	Slow, bright.
,, 25 ...	5	+ 11	Slow, short.
,, —Sept. ...	346	0	Slow.
,, —Oct. 2...	74	+ 42	Swift, streaks.
,, —Sept. ...	63	+ 22	Swift, streaks.

DOUBLE STARS AND CLUSTERS.—The tables of these, given three years ago, are again available, and readers are referred to the corresponding month of three years ago.

VARIABLE STARS.—Stars reaching their maxima in or near July, 1915, are included. The lists in recent months may also be consulted (see Table 37).

TABLE 37. LONG-PERIOD VARIABLE STARS.

Star.	Right Ascension. h. m. s.	Declination. ° ′	Magnitudes.	Period. d.	Date of Maximum.
R Ceti	2 21 42	− 0 34	7·5 to 12·8	167	1915—Aug. 21
R Tauri	4 23 38	+ 9 58	7·4 to 13·8	325	,, Sept. 21
U Orionis	5 50 47	+20 10	5·8 to 12·1	375	,, Sept. 11
RY Ursae Maj.	12 16 23	+61 45	7·2 to 8·3	315	,, Aug. 20 (Min)
RS Virginis	14 23 1	+ 5 4	7·0 to 13·8	355	,, Aug. 30
AF Cygni	19 27 40	+45 58	6·9 to 8·0	94	,, Sept. 4

Night Minima of Algol $12^d\ 5^h\cdot8\ m$, $15^d\ 2^h\cdot6\ m$, $17^d\ 11^h\cdot4\ e$, $20^d\ 8^h\cdot3\ e$, $23^d\ 5^h\cdot1\ e$. Period $2^d\ 20^h\ 48^m\cdot9$.

Principal Minima of β Lyrae August $3^d\ 7^h\cdot8\ e$, $16^d\ 5^h\cdot9\ e$, $29^d\ 4^h\cdot0\ e$. Period $12^d\ 21^h\ 47^m\cdot5$.

MEAN TIME OF MERIDIAN TRANSIT AT GREENWICH OF CERTAIN BRIGHT STARS.—It has been suggested to me that such a Table would be of service to observers for obtaining time by small transit instruments.

To find the Greenwich time of these stars crossing other meridians, express their longitude in time, diminish it by $9^s{\cdot}83$ for each hour of longitude, then add the result to the above times for West longitudes; subtract it for East longitudes. The times of transit for intermediate days may be obtained by simple interpolation.

TABLE 38.

Star.	Vega.	Altair.	α Cygni.
Declination.	N. 38° 42′.	N 8° 39′.	N. 44° 59′.
	h. m. s.	h. m. s.	h. m. s.
July 30	10 4 17·46 *e*	11 16 40·66 *e*	12 8 25·59 *m**
Aug. 9	9 24 58·26 *e*	10 37 21·58 *e*	11 29 6·52 *e*
,, 19	8 45 39·03 *e*	9 58 2·47 *e*	10 49 47·41 *e*
,, 29	8 6 19·75 *e*	9 18 43·32 *e*	10 10 28·24 *e*

* Morning of July 31st.

The SUN is after Clock $372^s{\cdot}47$ Aug. 1, $349^s{\cdot}83$ Aug. 6, $312^s{\cdot}60$ Aug. 11, $261^s{\cdot}06$ Aug. 16, $195^s{\cdot}93$ Aug. 21, $118^s{\cdot}71$ Aug. 26, $31^s{\cdot}51$ Aug. 31.

IXODOIDEA (BANKS).

By C. D. SOAR, F.L.S., F.R.M.S.

BANKS divides the super-family Ixodoidea into two families, as follows:—

No scutum; no ventral shield; mouth-parts of adult not prominent from above; no pulvillus to tarsus in adults.—Argasidae.

Scutum present; sometimes ventral shields; mouth-parts of adults prominent from above; pulvillus to tarsus of adults.—Ixodidae.

Neumann, in "Das Tierreich," makes a somewhat different arrangement. He first divides the family Ixodidae into two sub-families (A, Ixodinae, and B, Spelaeorhynchinae), and then the Ixodinae into two sections (I, Ixodini, and II, Argatini), the latter of which corresponds with the Argasidae of Banks. There always have been differences of opinion as regards classification among writers, and there always will be. However, it does not make any great difficulties, if the generic and specific names be allowed to rest.

Members of this super-family are very well known as ticks. Their bodies are covered with a tough, leathery skin, which in the female is capable of great expansion. A noticeable feature on the dorsal surface is a shield, which, although small in the females, almost entirely covers the dorsal surface of the males. This is known as the "scutum." It is quite absent in the Argasidae. The capitulum carries the palps and mandibular sheaths. Projecting well forward from the capitulum, in between the palps, is a tongue-like piece, known as the hypostome, which lies ventrally underneath the mandibles, and is best seen from the ventral side. Its ventral surface is armed with numerous minute teeth, known as "denticles," whose points are directed towards the body, and the formation of these denticles is an important character in that classification of ticks. The legs have six segments. The plates attached to the body (which corresponds with the epimera in the water-mites) are placed rather close together, but appear wider apart in the enlarged female. On the tarsus of the first pair of legs, near the distal end, is Haller's organ, which is supposed to be an organ of hearing. These mites do not all have eyes, but where they are found they are small.

The internal anatomy has been studied by H. A. Pagenstecker, but it has been the external structure which has received the greatest amount of attention.

The life-history of ticks has been described by several writers. They pair on their host. The female swells to an enormous size, and when ready to deposit her ova she leaves the host, on which she has been living, and drops to the ground. Here, either on the surface of the ground or just below it, she deposits large numbers of eggs in clusters. It has been computed that a female tick will deposit from ten thousand to twenty thousand eggs. They issue in elongated clusters from the front of the tick. The eggs are somewhat oval in shape, and usually of a dark brown colour. They are coated with a viscous substance for protection. How long the eggs lie before hatching is governed by the temperature, environment, and the species to which the eggs belong. The time varies from a few days to a month. Curtice says the Texas-fever tick takes from three to four weeks. The young ticks, when first born, are hexapod, having only six legs, the same as we find with most other mites. They are of a light colour, which gradually darkens to a rich brown tint, when they are known as "seed ticks." They ascend the grass and bushes, and wait for some warm-blooded animal to come along, so that they can attach themselves to it. In the case of the species known as blue ticks, Dixon and Spreull say that the larvae, on hatching, ascend the grass or bush, and as many as two thousand two hundred and fifty larvae have been counted on the top of a single blade of grass; also that by day and night, through wind, rain, and light frost, they remain at their post, waiting for something to come along; and specimens have been found still living, after three months of this weary vigil, showing how well adapted they must be to go without food for so long a time. They do not all secure a host; those that do begin business at once. The others die of starvation. Those that are fortunate enough to secure a host grow very rapidly, and in a few days are ready to undergo their next change. Most species drop the mite from their host and hide in the earth or grass, change their skin, and emerge as the nymph. At this stage it has eight legs, but is without the developed genital area we find in the adult. It now again ascends the grass and bushes, and goes through the waiting period for another host. After a few more days of this parasitic life it again drops to the earth, changes its skin, emerges as an adult, and becomes parasitic again. Its life-history is supposed to last from two to three months. Both changes in the blue tick take place on their host; the female only drops to the ground when ready to deposit its ova.

XUM

If there is one super-family of the Acarina which should receive more attention than another in all countries, it is that of the ticks. They can be found free, but more often they are found parasitic on mammals, birds, and reptiles. The damage that they can do their hosts, not so much by their blood-sucking as by conveying disease from one animal to another, is well known A number of diseases of domestic animals is due to blood parasites which have been conveyed by ticks from an infected host to a previously healthy one. In our own country, the disease amongst sheep known as louping-ill is supposed to be conveyed by a tick from one sheep to another. The tick which has the credit for this is *Ixodes ricinus* Latr. Abroad there is *Margaropus annulatus* Say, which is the transmitter of Texas fever. Then there are others, responsible for the conveyance of Southern cattle fever, red water, and heart water. Man himself does not escape from their unwelcome attentions, for some ticks are not at all particular as to which warm-blooded host they fasten themselves. Belt, in "Nicaragua," Chapter XI, speaks of the torment caused by ticks. In Persia, if all be true, a tick known as *Argas persicus* Fisch. causes terrible trouble in the exercising of its bloodthirsty propensities. Then there is a human tick fever on the Congo traced to *Ornithodoros moubata* Murr. In Neumann's list of different ticks found on one host, he gives twenty-two as having been found on man; twenty-eight on the dog. But the animal which appears to entertain the greatest number is the ox. As many as forty-one species have been found on *Bos taurus*.

Enough has been said here to show that a great deal of work has been done with the Ixodoidea, but there is plenty more to do. There is no section of the Acarina which causes more inconvenience to man or animals.

The "Cambridge Natural History," Vol. IV, tells us that a monograph by Mittall, Warburton, Cooper, and Robinson is about to be published, which will give all interested in the study of these little animals a good text-book to work with. Of all the Acarina, the ticks have no doubt received more attention than any others in recent years. Their natural habit of attacking both man and beast has no doubt been the means of their forcing themselves upon man's attention. Mr. E. G. Wheler, in *Science Gossip*, Vols. VI, VII, VIII (New Series), has given a very good and interesting series of articles on ticks, in which he has described, and shown photographs of, a number of British species. The great authority on ticks is L. G. Neumann. His works are invaluable to a student of the Ixodidae. There is also a book, published by the U.S. Department of Agriculture (1902), on "Cattle Ticks of the United States," by D. E. Salmon and Ch. Wardell Stiles, which is a most interesting work, well illustrated. Some of the coloured figures are beautiful. Another paper, published in U.S.A., which it is also well to have, is "A Treatise on the Acarina or Mites," by Nathan Banks, which gives a good introduction to the subject. But Neumann's "Das Tierreich" gives a bibliography of all the best books and papers on the subject, and the Concilium Bibliographicum, Zürich, will supply to anyone requiring it a list of papers which have since appeared.

"THE CHANGE IN THE CLIMATE AND ITS CAUSE."

By THE REV. M. DAVIDSON, B.A., M.Sc., F.R.A.S.

NOT long ago a book entitled "The Change in the Climate and its Cause," by Major R. A. Marriott, D.S.O., made its appearance, and I have written this article in the hope that some light may be thrown upon the views held there—views which, I believe, will not find general acceptance in the astronomical world.

In criticising this book it is necessary to go back a good many years. In 1873 a work entitled "The Cause, Date, and Duration of the Last Glacial Epoch" appeared, the author being the late Major-General A. W. Drayson. The following year another volume came out as a sequel to this, the title being "The Cause of the Supposed Proper Motion of the Fixed Stars"; and in 1888 "Thirty Thousand Years of the Earth's Past History" was published. In 1911 Admiral Sir Algernon F. R. De Horsey brought out "Draysonia," which was intended to explain more fully Drayson's system. It contains many examples, fully worked out, to show the application of Drayson's theory to the determination of the obliquity of the ecliptic, stellar positions, precession, and so on. Major Marriott's work gives a further explanation of the theory, and its bearing upon climatal changes: these latter are cited as corroborative evidence of the truth of Drayson's theory.

As it is impossible within the limitations of this article to deal very fully with the subject, I shall endeavour briefly to indicate what this theory is, and to show that its so-called applications are more apparent than real. In doing so, we must assume a certain amount of astronomical knowledge on the part of the readers, as, otherwise, too much space would necessarily be devoted to ordinary explanations. Drayson believed that, in addition to the daily rotation of the Earth upon its axis, there was also a slow rotation taking place around another axis, the arc between the poles of the two axes being 29° 25′ 47″. As the pole of the ecliptic is distant from the pole of the heavens by about 23° 27′ 3″ at present, the pole of the second axis of rotation would be 6° from the pole of the ecliptic. A complete revolution would be accomplished, he believed, in thirty-one thousand six hundred and eighty-two years; and as the obliquity of the ecliptic is measured by the arc between the pole of the heavens and the pole of the ecliptic, this obliquity would vary considerably, its greatest and least values being the sum and difference respectively of 29° 25′ 47″ and 6°, that is, 35° 25′ 47″ and 23° 25′ 47″.

For an explanation of the causes of precession and nutation I must refer readers to any elementary text-book of astronomy. The conical movement of the Earth's axis, by means of which it is carried around the pole of the ecliptic in twenty-five thousand eight hundred and sixty-seven years, appears to have puzzled both Drayson and his followers. Thus, on page 92 of "Thirty Thousand Years of the Earth's Past History," he gravely says: "The mere statement that the Earth's axis traces a conical movement, when no mention is made of which pole remains fixed, is a vague statement, utterly deficient in detail. That such a movement, if it occurred, would throw the centre of gravity out of its orbit did not seem to have been even considered." We need do no more than point out that each semi-axis of the Earth describes a similar cone, the apex of each cone being at the centre of the Earth, which point we may regard as fixed. It is difficult to understand how such a question should have been raised.

We shall now inquire into the problems which are solved by the aid of this system—problems which will be found in all the works cited. First of all, the question of the obliquity of the ecliptic will occupy our attention: a calculation is shown on page 37 of Marriott's book, and on page 28 of De Horsey's "Draysonia." The formulae used are, I imagine, based upon the elementary formula for the solution of a spherical triangle, $\cos a = \cos b \cos c + \sin b \sin c \cos A$, where the symbols correspond with the following in the first work mentioned:—

a=OE, that is, the distance of the pole of the heavens from the pole of the ecliptic, or the obliquity of the ecliptic.

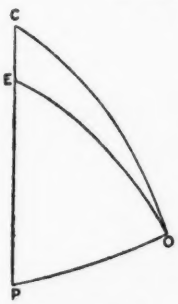

FIGURE 199.

b=OC, that is, the distance of the pole of the heavens from the pole of the second axis of rotation, which, according to Drayson, is always 29° 25′ 47″.

c=CE, that is, the distance of the pole of the second axis of rotation from the pole of the ecliptic, which is also constant, being always 6°.

A=angle ECO.—This angle is found by assuming that it changes 40″·9 annually, and that its value will be zero in A.D. 2295.

When the formulae are used by all three authors for computing the obliquity, formulae which are adapted for logarithmic computation, but which are based upon the above, we must admit that values are found which are nearly correct. For this reason some might be led to attribute a certain importance to the theory, if, as Major Marriott says, "Drayson can compute the obliquity of the ecliptic for any year, past or future, without observation." We shall now proceed to show that such a computation cannot be made with accuracy.

We should notice, in the first place, that the side c is only 6°, and that therefore its sine is small. In the next place, the angle A was less than 8° in A.D. 1600, and will be only 3° 20′ 29″ in A.D. 2000, decreasing gradually until it becomes zero in A.D. 2295. Now it is clear that within certain limits we can change A without producing great changes in the value of cos a, for the value of sin b sin c is only ·05136. In A.D. 1600 cos A = ·9905675, and in A.D. 1900 cos A = ·9969515; hence, even over this period, there will not be much alteration in the value of the expression sin b sin c cos A, and, as we have just pointed out, it always remains small, never exceeding ·05136. For this reason there is nothing remarkable in the formula applying approximately over comparatively short periods of time. To test its accuracy we should try to apply it over long epochs, and compare the conclusions with facts obtained by observation. I have done this, and give the results below. The "zero year," that is, the year when the obliquity was a minimum, is taken to be A.D. 2296 by Drayson, 2295 by Marriott, and 2294·75 by De Horsey. The difference, however, is of no practical importance, not affecting the results of the calculations, except in fractions of a second. I have taken 2296 in my calculations (see Table 39).

Probably it will be argued that the determinations by the early observers are untrustworthy. It may be true that the very earliest are correct only to the nearest minute of arc; but this still leaves a very wide margin of error by Drayson's method of calculation. The figures require little comment. An error of more than one degree is too serious to ignore. Even the more modern determination of the obliquity by the Arabians shows that Drayson's method is only approximate to within about ten minutes of arc. It seems very remarkable that Drayson and his admirers should not have tried to apply the method over long periods.

As we come up to more recent times the error diminishes. This is to be expected, because the diminution of the angle A causes the formula we have given to approach more closely to the form $\cos a = \cos b \cos c + \sin b \sin c$, or $a = b - c$, that is, a=29° 25′ 47″ − 6°=23° 25′ 47″, which is not far from the obliquity in recent times. By assuming that the formula held exactly for long periods as it holds approximately for short periods, an obliquity of 35° 25′ 47″ was found for 13544 B.C. As is well known, astronomers do not believe that the obliquity ever reached such a value; a variation of about 1° 18′ 41″ on either side of 23° 17′ 17″, the mean value, is the limit. The discussion of the reasons for assigning these limits is quite beyond the space allotted for this article. In spite of Major Marriott's criticism on page 64, where he points out that La Place could not get away from the assumption that the pole of the ecliptic was the centre of the curve described by the pole of the heavens, we are still willing to accept the results of his investigations on the changes of the obliquity being limited to a total variation of less than 3°.

It scarcely seems necessary to dwell on the other problems which are supposed to be capable of solution by this method. We have shown that it breaks down utterly when applied to the obliquity. Does the same thing hold with reference to precession and to the positions of the stars? De Horsey gives a formula on page 20 of "Draysonia" which may be expressed as follows: $\pi = 20{\cdot}0529 \cos \alpha$, where π is the annual precession in declination and α the right ascension of the star. This formula gives results which are fairly accurate, but this approximate accuracy can be explained by the fact that it is almost identical with the formula an astronomer would use for finding the precession in declination, assuming the precession of the equinoxes to take place in accordance with the usually accepted facts. Without going into the proof, I may merely state that the annual precession in declination can be represented by the formula $P = 50''{\cdot}2 \cos \alpha \sin \omega$, where ω is the obliquity of the ecliptic, and α the right ascension of the star. If we take ω to be 23° 27′ 4″, this reduces to $P = 19{\cdot}978 \cos \alpha$, which is almost identical with De Horsey's formula. Here, again, if we are willing to ignore small errors, the formula based upon Drayson's system appears to give nearly correct results. If it were applied for a long period of time, when ω had varied by about 30′, the method could make no claim even to an approximation. We may point out that Admiral De Horsey appears to be under an utter misapprehension about the subject of aberration. On page 21 he says that he will possibly be told that the motion of a star in right ascension and declination is properly termed "aberration." I think no astronomers are likely to confuse precession with aberration, which is an entirely different phenomenon, depending upon the orbital velocity of the Earth and the velocity of light. "Some of us may suffer from aberration of the intellect; perhaps I do," he continues. Certainly those who fail to distinguish between aberration and precession lay themselves open to the charge.

The method professes to find the right ascension and the declination of stars for any date, past or future. This, *inter alia*, will be found under the comparative summary given on page 17 of Major Marriott's work. That it can do so over comparatively short periods of time with small errors none of us will deny. But when we remember that the method ignores the proper motion of the fixed stars, or, rather, professes to explain the "so-called proper motions," we must receive it with some hesitation. In

TABLE 39.

Date.	Obliquity calculated by Drayson's Method.	Obliquity found by Observation.	Names of Observers.	Error by Drayson's Method.
B.C. 1100	24° 59′ 46″	23° 54′ 3″	Tcheon Kong	1° 5′ 43″
B.C. 160	24 16 33	23 45 52	Chinese	0 30 41
A.D. 827	23 43 40	23 33 52	Arabians at Baghdad	0 9 48

XUM

Chapter X of his work, published in 1874, Drayson explains "The Cause of the so-called Proper Motion of the Fixed Stars." The second axis of rotation is the key to the problem, and, apparently, astronomers had fallen into serious errors by overlooking this important consideration. It is certainly difficult to discuss the whole question of stellar motions in an article like this; but if Major Marriott believes that assigning proper motions to the stars was only a scheme for overcoming a difficulty, and that "every star whose position did not agree with the theory was assigned a proper motion of its own" (page 42, "The Change in the Climate"), may I refer him to the spectroscopic method of determining stellar motions? A recent work, by Dr. Campbell, Director of the Lick Observatory, was published in 1913, and gives a very good account of this important branch. Adherents of the second axis of rotation theory would do well to study carefully Dr. Campbell's "Stellar Motions, with Special Reference to Motions determined by Means of the Spectrograph." They will not, perhaps, find the necessity for appealing to a second axis of rotation to explain the motions of the stars.

The final point which we propose to discuss is that of climatal changes. The second rotation of the Earth would have brought about the condition of maximum obliquity about the year 13544 B.C., an obliquity amounting to 35° 25′ 47″. Thus the Arctic Circle would have been brought down to about latitude 54½° at this time, and in middle latitudes an arctic climate would prevail in winter, and tropical conditions in the summer. There would follow from these variations in climate *annual* migrations of the animals, and in this way we are able to account for the remains of tropical and arctic animals being found in the same drift. Major Marriott cites the views of American geologists on pages 69 and 70, the evidence apparently showing that the last Glacial epoch was of more modern date than had generally been supposed. Drayson's theory would give an obliquity twenty-three thousand years ago of a magnitude sufficient to inaugurate a Glacial period, and the obliquity had diminished sufficiently seven thousand years ago to cause the glacial conditions gradually to pass away. The author is struck by the apparent agreement between the astronomical and the geological evidence. "The empirical science of geology," he says, "is thus confirmed by the exact science of geometry with astonishing precision" (page 72).

If we understand this theory of climatic changes aright, the heat of the summers during the period of great obliquity liberated the icebergs formed in the winter, and these were scattered into localities of lower latitudes. If an arctic winter had continued uninterruptedly for thousands of years, no icebergs would be liberated from arctic regions or be seen in the Atlantic. The hot summers which would prevail during the time of great obliquity were as necessary to account for the dispersion of icebergs as the cold of winter to produce ice. When the obliquity has reached a minimum, in A.D. 2295, Major Marriott promises us the apex of the genial period when the contrast between summer and winter will be least. The fact that Grimsby fishermen encountered floating ice in great quantities round the Faroe Islands some years ago, and also that Iceland had no snow and scarcely any frost in mid-December, 1910, are given as corroborative evidence, amongst others, of an approach of genial conditions.

That the small diminution in the obliquity is responsible for these facts will not, I think, receive general acceptance. The fallacy of *post hoc, ergo propter hoc*, is one into which we are all liable to fall at times. Why the diminution of the obliquity should be held responsible for local variations of climate, or, indeed, for a universal change, is not quite clear. Atmospheric dust, sunspots, volcanic activity, variations in both oceanic and aërial currents, and many other agencies, have far more influence in producing changes of climate than a diminution or an increase of the obliquity, if, indeed, this has any practical effect at all. Again, is Major Marriott prepared to defend the theory of the annual migrations of the animals advocated on page 47 of "Thirty Thousand Years of the Earth's Past History"? We can scarcely describe animals like the elephant, rhinoceros, and hippopotamus as migratory. Even if we grant the possibility of these animals performing great annual migrations, how are we to explain the presence of two very different floras and molluscous faunas in the Pleistocene deposits of Middle Europe on any theory of "annual migrations"? The case against the annual migration theory has been stated by various writers, amongst whom we may refer to the late Lord Avebury, in Chapter IX of the last edition of "Prehistoric Times"; to Professor J. Geikie, in his "Prehistoric Europe," page 65, as well as in "The Great Ice Age." The arguments will be found very clearly summed up in these works.

Enough has probably been said to show that the theory of a second axis of rotation is quite untenable, and its acceptance leads to contradictions, inconsistencies, and grotesque hypotheses. It is, indeed, clothed with a semblance of reality when it appears to give accurate results for the obliquity, precession, and so on. As we have shown, these results are approximate only over short periods, and are utterly untrustworthy for long epochs. Finally, the dynamical problems raised in the mind of the present writer by a consideration of a body like our Earth, possessing at the same time two axes of rotation, are of such a formidable nature that he must candidly admit them to be entirely beyond his powers of adequate solution.

REVIEWS.

ARCHAEOLOGY.

The Paraclete and Mahdi, or the Exact Testimony of Science to Revelation and Exposition of the most Ancient Mysteries and Cults.—By JOCK LOCKE ESTENS, M.P.S., Sydney. 9¾-in. × 6-in. 498 pages. 79 plates.

(Sir Isaac Pitman & Sons. Price 31/6 net.)

This highly curious work is further described as "Identification of Britain as the 'Sacred Isles of the West'; of the British as the original Aryan race; and of the Druids as the custodians of the first oracles and geometric covenants of God. An interpretation of primeval signs, symbols, signets, and coins." The author apparently claims to write under inspiration, believing himself to be the recipient of a special revelation from the Eternal Source of Things. The first chapter introduces us to visions in which Mahomet plays a leading part, one of the author's objects being to effect a reconciliation between Christianity and Islam. But his chief end is to show a common origin for the various religious cults of the past by an attempted interpretation of their symbols, which origin is identified with Druidism. There can be no doubt that quasi-geometrical and arithmetical notions assumed a great importance in the minds of many early thinkers (*e.g.*, Pythagoras and Plato), and that much value was placed (*vide* the Kabalah) on words and numbers, and the supposed connections between them. These views have left their traces in many diverse stations, and Mr. Estens has undoubtedly collected an immense amount of information relative thereto, which may be of use to the student who is able to dig it out of the morass of a book in which it is embedded. Probably the labour involved would be greater than that needed to obtain the information from the original sources, in which case the book can be recommended only to psychologists interested in the phenomena of hallucination—for in such category, I think, must we place the author's experiences—as an interesting, albeit unwieldy, datum. That the style of the book is quaint, as the editor remarks, must, at any rate, be admitted, and the author's sincerity is beyond question.

H. S. REDGROVE.

BOTANY.

A Popular Dictionary of Botanical Names and Terms with their English Equivalents.—By GEORGE FREDERICK ZIMMER, F.R.H.S., F.Z.S. 122 pages. 7½-in. × 5-in.

(George Routledge & Sons. Price 2/6 net.)

Without being unduly long, verbose, or expensive, Mr. Zimmer's "Dictionary of Botanical Terms" will well serve to explain to botanists, and perhaps more particularly to horticulturists or the growers of plants, the meaning of a very large number of technical terms and Latin names.

W. M. W.

CHEMISTRY.

Practical Physical Chemistry.—By A. FINDLAY, M.A., D.Sc. 327 pages. 105 illustrations. 7¾-in. × 5¼-in.

(Longmans, Green & Co. Price 4/6 net.)

The fact that a third edition of this handbook has been demanded within a few years of its first appearance is a matter for congratulation to the author, and a proof that it has continued to supply a want. While the general arrangement of the book has been preserved, many new features have been added, as, for example, the electrical heating and control of thermostats and the estimation of the hydrolysis of salts by the measurement of the electrical conductivity of the solution. The value of the book is also enhanced by references to original papers and by the addition of an Appendix of Tables of Physical Data needed in practical work. No better guide to the subject could be desired by any student who is taking up what is perhaps now the most important branch of the science. It forms an admirable introduction to the advanced treatises on physical chemistry.

C. A. M.

GEOGRAPHY.

Principles of Physical Geography.—By G. C. FRY. 151 pages. 51 figures. 7-in. × 5-in.

(University Tutorial Press. Price 1/6.)

This book is an attempt to encompass within small space an account of the many branches of physical geography. The author is to be congratulated on the success which has attended the attempt, as the discussion of the various subjects, though necessarily short, is exceedingly clear. The text is amplified by numerous figures, and a useful index is appended. We notice, however, an occasional looseness of diction, while the use of such a phrase as "intruded lava" is to be deprecated, as is also the classification of the igneous rocks with the Pre-Cambrian. Typographical errors are rare, the most noticeable occurring in the text references at the foot of Figures 41 and 42.

A. S.

The English Countryside.—By ERNEST C. PULBROOK 120 pages. 126 illustrations. 9¼-in. × 6¾-in.

(B. T. Batsford. Price 7/6 net.)

Mr. Pulbrook's brightly written and excellently illustrated book carries one's thoughts away from the war to fords and crossing-places, to by-roads and trackways, to market and wayside crosses, to old inns and farmhouse interiors. If one does remember at all the turmoil which is going on, it is with deepest feelings of thankfulness that our own beautiful country has suffered but little damage. The geologist will be interested in the photographs showing coast erosion; the archaeologist will notice much that will please him; while the nature-lover and the general reader will find even more to attract them.

W. M. W.

Coast Sand Dunes, Sand Spits, and Sand Wastes.—By G. O. CASE. 162 pages. 43 figures. 7½-in. × 5-in.

(St. Bride's Press. Price 5/- net.)

Although on the Continent of Europe, and in various other parts of the world, vast areas of the sand wastes which fringe the coasts have been reclaimed, and are now productive land, chiefly forested, little attention has hitherto been paid in this country to the advisability of controlling the drifting of sand and the erosion of the coast, and of making use of what are waste lands. To leave these wastes alone, as, for the most part, is done in Britain, is not merely to lose the advantage of many square miles of potential forest, but to expose even larger areas inland from the actual coast-line to the ravages of blown sand, and in many cases to allow extensive erosion of the coast to go on unchecked. The author deals in detail with this subject, pointing out what has been, and might with but little expenditure be, done in the direction of preventing inland sand drift, of protecting the coast against erosion, and in not only enabling, but making commercially well worth while, the reclamation and conversion into beautiful pine forests of the existing areas of sand wastes and useless sand-dune belts at present barren, or only partially covered by vegetation. The subject is of more than economic interest, and appeals strongly to geographers and plant ecologists.

F. C.

MATERIA MEDICA.

Squire's Pocket Companion to the British Pharmacopoeia.—By PETER WYATT SQUIRE. 1040 pages. 6¾-in. × 4¼-in.

(J. & A. Churchill. Price 10/6 net.)

Although of a size which enables it easily to be carried in the pocket, the second edition of "Squire's Pocket Companion" contains over a thousand pages, in which details of official and non-official drugs are given. The various substances are treated in alphabetical order, and they are described with notes as to their preparation, solubility, and medical properties. There are also given notes of use in prescribing and the amount of the dose. The claim that the book contains information on all matters commonly arising in the course of prescribing and dispensing, to the great advantage of the prescriber and the dispenser, is well substantiated.

W. M. W.

NATURAL HISTORY.

Transactions of the Paisley Naturalists' Society. Vol. II. 120 pages. 1 map. 8¾-in. × 5¾-in.

(Paisley: Alexander Gardner. Price 3/6 net.)

The Rev. Charles A. Hall contributes some introductory notes to this volume. The geology of Renfrewshire was dealt with in the first volume, but the present one contains a geological map of the county. Mr. Hall tells us a good deal about the characteristics of Renfrewshire, and also about the activities of the local society which is studying plant ecology, and has recently instituted a section which is to pay special attention to nature photography and microscopy. The volume gives an account of the plants, macrolepidoptera, fishes, amphibians, reptiles, birds, and mammals of Renfrewshire. There is also an account of the fossils in the Paisley Museum and the history of the Paisley Naturalists' Society, which has now been in existence for twenty-one years.

W. M. W.

PHYSICS.

Liquid Drops and Globules.—By CHARLES R. DARLING. 83 pages. 43 figures. 7½-in. × 5-in.

(E. & F. N. Spon. Price 2/6 net.)

Our readers will recollect the interesting articles which have appeared in "KNOWLEDGE," by Mr. Charles Darling, describing his remarkable experiments with drops. He recently gave three lectures on this and other branches of his work, and these, which are now published and fully illustrated, form the present little book. It will prove exceedingly useful for reference.

W. M. W.

XUM

RADIO-ACTIVITY.

Radiography, X-ray Therapeutics, and Radium Therapy.—By ROBERT KNOX, M.D. 406 pages. 246 illustrations. 64 plates and a frontispiece in colour. 10-in. × 6½-in.

(A. & C. Black. Price 25/- net.)

This book is written to present to the student and the practitioner in "as concise and practical a form as possible the essential points" in the application of the short-wave radiations to medical science. The physics of the *x* and radium rays are, of course, far from simple, and it is not possible to fulfil the object of the book as stated above by using only the facts usually taught in a medical curriculum. This fact has for long been ignored by most of the medical profession, but it is evident that Dr. Knox harbours no delusions on the point. As a result, we have a number of chapters, about a quarter of the book, which are of great interest to students of "pure" science. The rest of the book is naturally of greater importance to the medical man, and can only be thoroughly appreciated by those possessing a full knowledge of medical terminology.

In the section of the book dealing with radiography, the chapters on *x*-ray tubes and the control of the vacuum in them, and on the localisation of foreign bodies, illustrate very well to what a large degree physical science is involved in the application of *x* rays to explore the interior structure of the body. We also note that the use of *x* rays has now advanced far beyond the point when they were of use merely in detection of abnormalities in connection with bones. Soft structures of the body, such as the heart, lungs, and intestine, can now be examined by this means.

In *x*-ray therapeutics the object is not to act with *x* rays on a screen or photographic plate outside the subject, but to allow the energy transmitted by the rays to be absorbed in some diseased tissue. This part of the subject is dealt with in the second portion of the book, which also contains a description of radium therapy. At the present time radiation therapeutics, in general, whether by *x* rays or by the rays of radio-active elements, are still in the very unsatisfactory state of "trial and error." Dr. Knox points this out, and shows that it is a common experience to find two growths of apparently similar nature responding differently to precisely similar conditions of ray and dosage. The impossibility of predetermining the exact results should not prohibit the recognition of the reality of the benefits obtained in many instances. In this part of the volume they are attested to by photographs which are most convincing.

Mr. C. E. S. Phillips contributes a chapter on the "Physics of Radium," and the volume is illustrated by many *x*-ray photographs, of which the negative, as well as the positive, is reproduced. The author is to be congratulated on the production, along scientific lines, of a most useful, practical book, which is of value to physicists as well as to medical men. It also inspires the hope that in the near future the labours of the doctors, electrical engineers, and radiation physicists will be coördinated to a much greater extent than they are at present, and that by this means the action of radiant energy on animal tissues will cease to be so uncertain as just now, and will become a controllable means of influencing and ameliorating the wastage of disease.

A. F.

NOTICES.

ADDITIONS TO THE ZOÖLOGICAL SOCIETY'S COLLECTION.—Among the more interesting additions to the menagerie at Regent's Park are a feline Douroucouli (*Aotes felinus*); two White-browed Hares (*Sylvilagus superciliaris*), presented by Mr. W. K. Pomeroy; a Reindeer born in the menagerie; and four Siamese Fighting Fish (*Betta pugnax*), new to the collection, presented by Mr. C. Lamont Groundwater.

THE HOUSE-FLY CAMPAIGN.—Following upon the house-fly exhibition at the Zoölogical Gardens, and the appearance of Major Hardy's book (published by Mr. William Heinemann), is the announcement by Messrs. Longmans, Green & Company that they will very shortly issue a volume entitled "The House-fly, a Slayer of Men," by F. W. Fitzsimons, F.Z.S., F.R.M.S., Director, Port Elizabeth Museum. The book will be fully illustrated.

Mr. Fitzsimons has for some years past carried out a vigorous campaign against the house-fly in South Africa. He is the author of a booklet on the same subject that was published under the auspices of the Central Good Hope Red Cross Committee, and supplied to the Union Defence Force previous to their embarking upon the present campaign in German South West Africa. The book will be published at 1s. net.

THE IMPERIAL INSTITUTE.—The successful series of public lectures on "The Empire," by Dr. H. B. Gray, the official lecturer, will be continued at the Imperial Institute throughout July. The lectures, which are now illustrated by lantern slides, are followed in each case by a visit to the Exhibition Galleries of the Imperial Institute, which afford a unique object lesson in the Empire's commercial capacities. The resources of the Colonies and India are exhaustively represented by specimens, and there are explanatory statements respecting the more important products of each country. Moreover, the ample space at South Kensington allows the collections to be kept up to date, and on a scale which would be impossible elsewhere, so that whenever the galleries are visited they may be relied on to give a complete representation of the Empire's resources.

The lectures for July, which will be given on Wednesdays at 3 o'clock punctually, are as follows: July 7th, "British West Africa"; July 14th, "Fiji, Western Pacific, and Falkland Islands"; July 21st, "Egypt and the Sudan." Admission is free by ticket, to be obtained at the Central Stand in the Exhibition Galleries, Imperial Institute, South Kensington, S.W.

MR. BAKER'S CATALOGUE OF MICROSCOPES.—As there are many microscopists who prefer instruments of the type used abroad, Mr. Charles Baker has produced two new stands, which are made in London. The first one, known as "D.A.," is similar in design to the Continental forms, but fitted with a built-on mechanical stage, which can be entirely removed by unscrewing a single milled head, so that a large square stage is left for an examination of a petri dish or sections of considerable size. Stand D is a copy of a Continental model, and the shape of the limb in this case also allows for the examination of an ordinary petri dish.

We may also mention the "Workshop" metallurgical microscope, which consists of two microscopes placed at an angle to one another, thus enabling the user to examine an object with both eyes. The instrument produces an enhanced stereoscopic effect, which is much appreciated in the examination of metals. An electric bulb and a bull's-eye condenser are fixed to the microscope for illuminating the specimen under examination. There is no fine adjustment, as only low magnifications can be obtained. An additional advantage is that the limb can be unclamped from the stage and placed on a special foot, so that surfaces can be examined of objects which are too large to be put upon the stage. There are many accessories described in and figured in the list, including electrical lamps, dark-ground illuminators, reflectors, warm stages, as well as apparatus for recording observations by drawing or photography.

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